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Kurt Williams on The Incredible Hulk

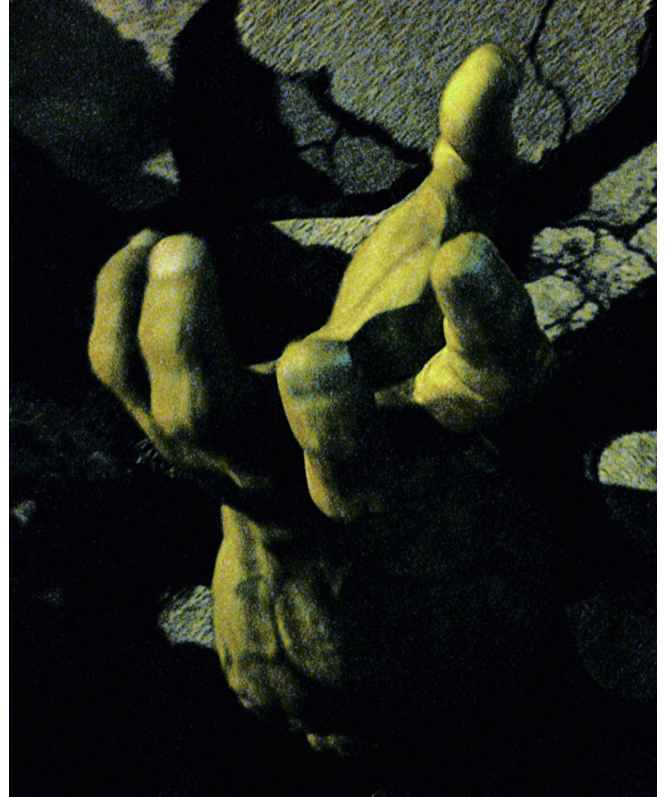
Article by Estelle Shay

Among the most enduring of the Marvel Comics superheroes is *The Incredible Hulk* — the raging alter ego of scientist Bruce Banner, whose exposure to gamma radiation causes him to transform into a giant muscle-bound fury whenever his temper flares. First introduced to comic book fans by Stan Lee and Jack Kirby in 1962, *The Hulk* has since enjoyed numerous comic reincarnations, starred in his own television series from 1978 to 1982, and even made the leap to the big screen in 2003 with a Universal Pictures movie directed by Ang Lee. Though that film, *The Hulk*, received a lukewarm reception, the new Marvel Studios, having since regained the rights to the property, was not ready to give up on the idea of a film franchise based on the iconic character.

In their newest undertaking, *The Incredible Hulk*, Marvel producers Avi Arad and Kevin Feige enlisted director Louis Leterrier and visual effects supervisor Kurt Williams to reinvigorate the material with an all-new *Hulk* that would resonate more with audiences. “*Hulk* is second only to *Spider-Man* in terms of character awareness in the marketplace,” noted Williams. “Even after the first movie, Avi and Kevin felt that there was still a lot of untapped potential in the character. They were absolutely passionate about making another movie, and one of the things we talked about was what do we want to do different? How do we want to portray *Hulk*?”

Key to the undertaking was an approach aimed at delving more deeply into the tortured psyche of Banner — now played by Edward Norton — and *Hulk*’s connection to him. “We went into this movie with a great amount of respect for the first film — what Ang Lee’s vision was, and the impressive work that ILM did on that character — but our goal was to create a *Hulk* that was a little more accessible, not only in his look but in how he acted. We wanted to really drive the line between Banner and *Hulk*, reinforcing that relationship throughout, and taking it on in less of a scientific way than an emotional way.”

The film’s visual effects challenges were considerable. Besides the *Hulk*, whose performance would anchor the film, the script introduced another character from the Marvel Comics universe — the Abomination — spawned when special forces soldier Emil Blonsky (Tim Roth) is injected with a derivative of *Hulk*’s irradiated blood. Animation chores involving the two computer generated



characters were complicated by scale issues related to their size, and by fast-paced action and moving cameras — a hallmark of Leterrier's spontaneous filmmaking style. Other effects included 3D and environment work required to enhance or transform the Toronto-based production's settings into locales ranging from an Arctic ice glacier to a Rio de Janeiro bottling factory to New York City, as Banner travels the globe searching for a cure.

To handle the effects work — an estimated 700 shots — Williams called upon several vendors, chief among them Rhythm & Hues, charged with creating *Hulk* and Abomination as all-CG characters. Sharing the workload was Hydraulx, which handled extensive compositing, digital doubles and environment work, and animated the fiery crash of an Apache helicopter for a key action sequence. Additional support was provided by two Canadian companies — Soho VFX, responsible for secondary character work and 3D effects, and Image Engine, which contributed several one-off shots involving a drop of Banner's infected blood, and virtual backgrounds for the film's finale. Gentle Giant Studios provided scanning for digital doubles and Amalgamated Dynamics offered up some minor prosthetics work.

Determined to get a jump on the characters prior to going to camera, Williams wasted no time in setting up a small design team headed by concept artist Aaron Sims. "The fear was that if we didn't see what *Hulk* was like prior to shooting, we really couldn't get the actors to understand him and relate to him." The brief for the character was simple, though its execution was not. "Even in his altered state, we wanted audiences to relate to *Hulk*. We didn't want him to come across as just a monster."

Specifically, Leterrier and Williams lobbied for certain changes in the look of the character. "We wanted to see more out of *Hulk*'s eyes and really make them a focal point — a window to his soul. We also wanted him to have long hair. Louis really pressed for that — wanting to go back to the original material from some of the great Marvel comic artists, where the hair was part of the character and not something that just sat idly on his head. It came down over his eyes; he looked through it; it was part and parcel of the weight and shape of his head. We felt that long hair would help people relate to *Hulk*."

Another key decision was to keep the character's size consistent throughout the story, rather than having him grow bigger as his anger escalates — a conceit that the filmmakers felt worked against the first film. "Our feeling was to keep it a little simpler, and create one size and presence for *Hulk*. We settled on a height of nine feet. It gave him a good relationship to people, where he still felt larger than life, but not so big that it would have been difficult to frame him in our anamorphic movie." The character designers also made the character more athletic-looking, while still retaining



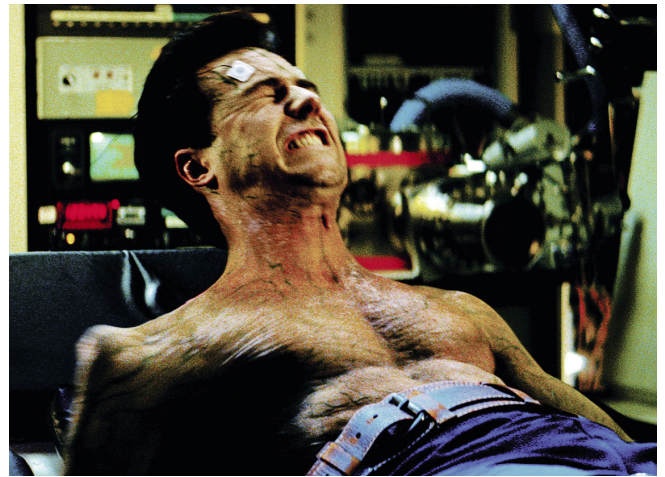
*Offering up a fresh cinematic approach to one of its most iconic creations, Marvel Studios joined forces with director Louis Leterrier for *The Incredible Hulk*, starring Edward Norton as scientist Dr. Bruce Banner. In the film, Banner battles military special forces intent on capturing him, while searching for an antidote to the gamma radiation poisoning that causes his stress-induced mutation into the raging giant known as the Hulk. Visual effects supervisor Kurt Williams engaged Rhythm & Hues to create the film's all-new Hulk, while Hydraulx, Soho VFX and Image Engine contributed to the ambitious slate of effects.*

his formidable muscular and physical stature. “We gave him enhanced, large hands, which was pragmatic on our part because he has to grab and throw things. At the same time, we wanted a leaner *Hulk* — unlike in a lot of the comics where he looks thick and almost soft-tissue. We wanted him to be able to move very quickly and have a lot of flexibility. We fought the idea that he would just walk around like a weightlifter.”

Hulk’s skin color was an especially sensitive issue, given the difficulty in making a green-skinned human come across as photoreal. Williams settled on a more organic-looking, less saturated color than the green hue used in the first film. “We targeted in skin colors that were somewhere between green and gray, with a dappled tone. We wanted to suggest anatomically that the blood in his vascular system, the tissue on his skin and the tissue under it have been affected by the gamma radiation.”

For the Abomination — whose on-screen time was limited to the movie’s finale — the filmmakers chose to deviate somewhat from the character’s comic book origins. “We wanted to create an iconic look for Abomination — something that was a little different, but would still make him a successful gamma radiation accident. So we gave him a gigantic skeletal cage that has literally grown on the outside of his body in a lot of places. You can see his sternum right through his skin. The bones on his elbows stick out; his heelbone has popped out, so he has this misshapen foot; and his hands are giant and gnarled with bones sticking out. His shoulder bones and vertebrae have grown to the outside and can change shape and flare up — which gave us a tool set for communicating his anger, almost like the hackles raising on a cat. It made him very threatening.” To underscore the 11-foot-tall behemoth’s less obvious human connection, facial features — in particular the eyes and mouth — were modeled after Tim Roth.

From 2D artwork, Sims translated his designs directly into 3D geometry for delivery to Rhythm & Hues, where the gauntlet was taken up by visual effects supervisor Betsy Paterson and animation supervisor Keith Roberts. “Even today, creating what we consider to be a CG human is not an easy thing. Very few people have done it really successfully; and even though we were refining work that was already out there, we were refining it in Rhythm & Hues’ proprietary system — Voodoo — which hadn’t been done before. So it was a



In a university laboratory, Banner transforms into the Hulk as part of an experiment designed to test a possible antidote. The organic-looking metamorphosis, digitally engineered by Rhythm & Hues in a series of closeups, included shots of green gamma blood pulsing through Banner’s veins, followed by agonizingly painful and irregular muscular-skeletal growth.



Having evaded all attempts at capture during a raid on the university, the nine-foot-tall Hulk confronts his dauntless military adversary, Emil Blonsky (Tim Roth).

huge challenge. The unit needed a long lead time in order to get all of the subsurface details, all the layers and tiny detailing that would make the character photoreal and visceral.”

To assist Paterson and her crew as they began creating the skeletal structures and experimenting with animation, Williams created a style guide that included Sims’ initial design work and extended to all aspects of the character development. “There was a full circle in our design process that was important. One of the things we were really concerned with was micro movements — not only micro movements in the eyes, but micro movements in the muscles and in the way the skin moves against musculature as it flexes. So we started by not only doing render tests, but also a lot of movement studies and motion capture that could give Keith a good start in the animation of the characters. Even after you’ve established the designs for a character, once you get him moving around, it changes. Suddenly the legs seem too big or too long, or he’s walking duck-footed, and you have to change the size or parameters of the body. We went through several studies, and then went back to Aaron. We would go in with Aaron’s 3D geometry; Rhythm & Hues would put that into action in a key set of short shots; then we’d sit with Aaron and with the whole R&H crew and make body changes to *Hulk* to get him the way we wanted.”



Blonsky, irreversibly transformed into the 11-foot-tall Abomination following an infusion of gamma-irradiated blood, breaks out of the university lab and terrorizes the streets of New York. Creature designs by concept artist Aaron Sims had the character exhibiting the requisite Hulk-like muscle mass, but with a less human, more threatening appearance that had misshapen bones protruding outside the body or visible through the skin. Rhythm & Hues animated and rendered the all-CG creature for the movie’s explosive finale, compositing him into backgrounds shot on location in Toronto and digitally altered to represent New York.

Motion capture at Giant Studios played a key role in the character development. Different body types were tested to see which would be best suited for the motion capture, and those were applied to the base models to see what they looked like and to ensure that the models had the necessary flexibility. Movement coach Terry Notary was engaged to further explore the movement and choreography for both *Hulk* and Abomination. “Motion capture has been, in the past, kind of an afterthought; but on this film we led the designs of *Hulk* and Abomination with motion capture — and that’s an important distinction. We started with designs, geometry and motion capture from the get-go. It was not just a 2D design or a maquette that suddenly changed into movement later, once the geometry was built.”

Previz by Pixel Liberation Front assisted the filmmakers in mapping out dynamic action for scenes in which *Hulk* battles special forces soldiers led by General Ross (William Hurt), who uses his military might to mercilessly track down Banner, intent on capturing him and harnessing his powers. “The previz helped us to establish the intent of each shot and plan for the marriage of physical effects with our CG characters. We would take that previzualization on the set as we shot, and we’d overcut takes just to make sure that we had everything we needed.”

On set, simple methods were used to establish eye-lines for the actors and to give the filmmakers a reference for framing. “There were so many hand-held shots, or shots filmed from a Technocrane, it was very important for the camera operators to know where our CG characters would be in a scene. So we hired stand-ins for *Hulk* and Abomination, and built backpack armatures for them to wear, with tennis balls that could be extended to the nine- or eleven-foot eye-line height.”

Most of the fight choreography relied heavily on interactive effects executed by special effects coordinator Laird McMurray and his crew, working in close collaboration with Williams and the visual effects teams. “We were constantly making decisions on which way to go — whether we’d go with CG or practical effects — hoping to avoid a lot of redundancy. We did extensive testing with special effects, with an eye to how the animatics were looking and where the handoffs would be. There were a lot of vehicles that had to be thrown around, and Laird’s crew came up with a special truck we called ‘the Abomination’ — basically an old fire truck equipped with an armature and a ram to push heavy cars or props or set dressing around. They could drive this thing in and set up in an hour. It became a priceless asset.”

Not all dynamic interactions could be captured in-camera. In one scene, an Apache helicopter performs a strafing run, sending bullets ripping up *Hulk*’s back as he shields Betty Ross (Liv Tyler) from harm. *Hulk* responds by throwing a piece of debris at the aircraft, shearing off one of its rotors and causing a spectacular crash, as the wreckage tumbles toward him and over him, engulfing him in a giant explosion of smoke and fire. Hydraulx, under visual effects supervisors Colin and Greg Strause, executed the complex sequence using tried-and-true hard-body dynamics to create a CG helicopter and simulate its fiery impact with the ground and with a CG *Hulk*, provided by Rhythm & Hues and Soho.

Later in the story, Banner and Betty meet up with Samuel Stearns (Tim Blake Nelson) who has been working on a possible antidote. In order to test it, however, Banner must first submit to electric shocks to trigger his body’s ‘Hulk-out’ response. The 30-shot sequence depicting Banner’s transformation into *Hulk* was one of Rhythm & Hues’ signature effects sequences, and a critical opportunity to drive home the Banner-*Hulk* connection. “We didn’t just want a ballooning effect. We wanted to give it a very organic feel and show the audience a full-on transformation, exposing exactly how it happens and hiding nothing — physically show the pain that Banner feels as his body starts to change.”



In a show of unbridled fury and strength, Hulk tosses aside two wrecked vehicles as he battles the rampaging Abomination. The brawl – which had the two gargantuans crashing through Harlem streets, up onto a building rooftop, then back to ground level – called for extensive previz and a heavy use of interactive physical effects filmed on location and seamlessly blended with complex character animation, 3D effects and virtual environments. The sequence showcased Rhythm & Hues’ all-new Hulk, whose look and performance Williams and his effects team continually sought to infuse with a vulnerable quality, driving home his connection to Banner and making him more accessible to audiences.

The transformation, rendered in dramatic closeup, begins with Banner's skin color fading, his veins altering as green gamma blood begins to pulse through them. Frenetic muscle twitching and irregular skeletal and muscle growth follow, with closeup views of his shoulder dislocating, growing, and then relocating in its socket. "Every shot in that sequence was a one-off rig for Rhythm & Hues. Normally, with a CG character, you try to come up with an approach that allows you to amortize the work over different shots or different parts of the movie. With this one, there was just no way to do that. Keith and Betsy and the Rhythm & Hues team just had to brute-force it, shot for shot, second for second."

Uncertain that the serum antidote is working, Betty jumps on *Hulk* in an effort to calm him. The interaction was achieved with a collapsible physical rig built by the special effects team to represent *Hulk*'s torso. "We didn't want to go to greenscreen and then have to match the lighting, or limit Louis' camera moves. With this body piece, Liv could physically jump on it and interact with it, and it would shrink down to represent *Hulk* shrinking back into Banner."

When Blonsky later forces Stearns to inject him with a derivative of *Hulk*'s infected blood, the results are apocryphal as the soldier transforms — irreversibly — into the Abomination, bursting out of the lab and onto the streets of Harlem, hellbent on destruction. *Intercut* with shots of Abomination terrorizing the city were those of Banner on the tailgate of Ross' Sikorsky helicopter, bidding goodbye to Betty, then freefalling to earth to face his nemesis.

On the ground, Banner — having once more transformed into the *Hulk* — faces off against the Abomination, and the two gargantuans collide head-on in a deadly brawl. "It's basically the biggest bar fight in history. It's Any Given Sunday on steroids. They crash down the street, through a burning bus, up a building and onto a rooftop, onto a helicopter and down into the street again for the final confrontation. And we have to believe that it's these two giants fighting; we have to feel their weight."

The complex action was divided into sections, with Hydraulx handling Banner's fall from the helicopter, Rhythm & Hues executing all of the hero character animation for the street-level fighting, and Soho tackling the rooftop sequence. Plate photography for the ground fight was captured during a four-night shoot on location in Toronto, where 200 vehicles had to be moved in each night as set dressing. "We didn't have the schedule to create full-on CG streets, so we committed to as much physical effects as possible, band-aiding two Toronto locations together where we could have the kind of giant explosions we needed."

For the rooftop fight, Williams opted for a different strategy, calling upon Soho visual effects supervisor Allan Magled and his team to create the rooftop as a virtual environment. "In that portion of the fight, Ross brings his Sikorsky down and starts firing on Abomination, who scrambles up a building and onto the rooftop, then leaps onto the bottom of the helicopter to take it down. *Hulk* jumps, as well, and they fight hanging from the helicopter, bringing it crashing down into a plaza. We committed to going all-CG on those shots from the beginning, because as the bar fight continues, we wanted a bit of a different look throughout the different aspects of it. So that's a complete CG environment that Soho did, along with all the character animation and the CG helicopter."

Following the helicopter crash, the fight continues on the ground with Rhythm & Hues animating the remainder of the brawl action, composited into background plates filmed on a practical plaza set piece. *Image Engine*, led by visual effects supervisor Robin Hackl, augmented and extended the plate photography for the 70-shot sequence, providing digital set extensions that entailed an extensive CG Harlem city build.

Not surprisingly, *The Incredible Hulk* ends with the hint that there just might be a sequel or two in the offing — a prospect that Williams entertains with relish. “I’m extremely proud of the look of our characters, and how we developed them with an eye toward creating for Marvel the potential for a number of other *Hulk* films. Not only has the technology come a long way, giving us a much better shot at creating more realistic characters — and on a shorter timetable — but I also think we succeeded in giving *Hulk* a much greater emotional range than he had in the last movie. Everybody knows about *Hulk* rage — that’s the iconic *Hulk*. But you also want to see the tortured Bruce Banner in him — the fact that he can’t cure himself. And that’s what we brought to this character.”

The Incredible Hulk photographs copyright © 2008 by Marvel Studios and Universal Pictures.

Joe Bauer on Get Smart

Article by Jody Duncan

In 1965, comedy writers Mel Brooks and Buck Henry funneled America's Cold War anxieties into a deft television spoof of the movie spy genre, called *Get Smart*. The series starred Don Adams as Maxwell Smart, a well-intentioned but bungling agent of CONTROL, a top-secret branch of the U.S. intelligence service. Aided by his beautiful and competent partner, Agent 99 — played by Barbara Feldon — Max, despite himself, bested the KGB-like agents of KAOS week after week throughout the show's five-year run.

Peter Segal directed the Warner Brothers film adaptation of the popular television series, which stars Steve Carell as Max, Anne Hathaway as 99, and Alan Arkin as CONTROL's chief. Production shot in and around Montreal, Washington D.C. and Moscow, and on stages at Warner Brothers. Segal assigned the supervision of the show's visual effects shots to Joe Bauer, who subsequently brought on Digital Dimension, Eden FX, Zoic Studios, Rising Sun Pictures, Pixel Magic, Look! Effects and Amalgamated Pixels to realize a variety of visual effects shots. Cinema Production Services contributed a miniature for a major action sequence.

The film's high-camp style and slightly updated 1960s' design aesthetic are established in its first moments: a black screen is suddenly illuminated by a flickering fluorescent light, revealing a metallic Warner Brothers logo realized by Zoic Studios and visual effects supervisors Patti Gannon and Randy Goux. "The director really wanted to incorporate the Warner Brothers logo into the film," observed Joe Bauer. "So after knocking around ideas for awhile, we decided to make the logo look like one of the series of big metallic doors Max walked through in the opening title sequence of the *Get Smart* television show."

Zoic's final logo animation has unlocking latches and door sections that open to reveal outer space and a KAOS satellite circling the earth, into which is incorporated the Village Roadshow logo. "The KAOS satellite passes us; and then the CONTROL satellite approaches us and we're looking at earth from outer space. Then we chase the CONTROL satellite around for the rest of the opening title sequence. This was an idea that came up very late, and so Zoic had maybe three weeks from start to finish to achieve both of those logos."



Zoic Studios also executed an early ‘corridor of doors’ sequence — a translation of the television series opening that has Max passing through a series of mechanical doors within a bunker environment. He finally stops at an incongruously placed phone booth, picks up the phone, dials a number, then suddenly drops out of frame, presumably descending to secret CONTROL headquarters below. Production designer Wynn Thomas designed a look for a variety of doors, and presented a cost analysis for building the entire environment in full-scale, complete with working mechanical doors. When production determined that a CG environment would be less expensive, the production design team built only a corridor floor and a section of wall with the phone booth on it. Production shot Steve Carell walking through the set, against greenscreen.

Zoic Studios computer generated all of the opening and closing doors, enhancing the original door designs. “We could make the door designs more intricate in digital than they would have been able to build for the cost. We kept adding functions to the doors, because the more each door did, the more interesting it got. But they still had to look mechanical. They couldn’t do anything that looked too high-tech or electronic. Some had turning hatches and rotating locks, others had spiked points that came out and retracted. There were three-section doors, two-section doors, gliders, barn doors — all kinds of shapes.” Zoic also extended the bunker environment, gathering textures from the set wall and duplicating it digitally, adding levels of concrete walls and flickering fluorescent lights. “We wanted this bunker to look as if it was built in the late Fifties or early Sixties, but had been upgraded now and again in the years since.”

The production design team built the interior of CONTROL as a complete full-scale set; but a large globe that was a centerpiece of the set had to be augmented by visual effects. “The globe was how CONTROL tracked all of its agents in the field. The production had built this globe with etched continents on it, and they hit areas where the agents were supposed to be with little laser points. But the on-set globe just didn’t look interesting or high-tech enough in the footage. So we had production’s graphics design vendor generate a series of graphics, and we supplied those to Look! Effects. Look post-tracked all of these shots at CONTROL — from which no information had been taken — and then laid these graphics onto the globe, mapping them in multiple layers.”

After CONTROL headquarters is hit by KAOS, Max joins the Chief and fellow agents at a secret meeting place, entered through a hatch in the reflecting pond at the Lincoln Memorial. The sequence starts with Max walking across the surface of the pond, and then punching buttons on a swimming duck decoy, which causes the hatch to open. The scene was made up of several different pieces, assembled and enhanced by Pixel Magic, with visual effects supervisor Ray McIntyre Jr. overseeing the project.

Joe Bauer shot the plate for the scene in Washington D.C. with a local crew, while production shot Steve Carell — on location in Russia at the time — on a raised set covered in mylar to simulate the reflection of the water and to reflect greenscreen around the actor’s legs and feet. Later, production shot the element of live ducks swimming in water at Renmar Studios in Hollywood. “Pixel Magic did a lot of simulated water work to make water displace off the ducks and so on. They also added foot splashes for Max that we’d shot — so that it would look as if he was interacting with the water when he walked across it — and splashes for when the secret hatch opens and closes.”

Amalgamated Pixels provided compositing for other shots set at the Lincoln Memorial, where Max interacts with Agent 13, played by Bill Murray.

To ensure that no KAOS bugs detect the secret meeting of CONTROL agents, the Chief agrees to make use of the ‘cone of silence,’ a recurring gag in the television series. Digital Dimension — with compositing lead Dan Levitan and computer graphics supervisor Andy Roberts leading the way — created the cone of silence shots. “The actors ad-libbed the cone of silence scene for a couple of days; and then, after the director and editor cut it together, we added the digital cone effect. We worked off of Wynn Thomas’ design to create an updated, modern version of the cone from the television series — which had been a physical, plastic thing that came down. Our version was an electronic, wine-glass-shaped projection that emitted a beam, reflected off of a point in the ceiling, and then encased each of the agents individually, emitting little bits of electricity. Digital Dimension did both 2D and 3D tests to create this effect, and wound up doing a combination of the two. They gave it a warping quality so that anything we saw through it — the characters, the set — would shift and distort.”

In the meeting, it is decided that Max and 99 will travel to Moscow to infiltrate KAOS operations there. Digital Dimension created a flashy shot to establish the pair aboard a Boeing 767, en route to Russia. “The director really wanted to open up this film and make it feel bigger than a typical comedy; and so he came up with this shot where we pick up the 767 from a distance, track all the way around it, move around a wing and over the engine, travel in through a passenger window, then follow a flight attendant down the aisle, ultimately picking up Max and 99 in their seats — all in one uninterrupted shot. All of that was digital until we got inside the airplane cabin.”



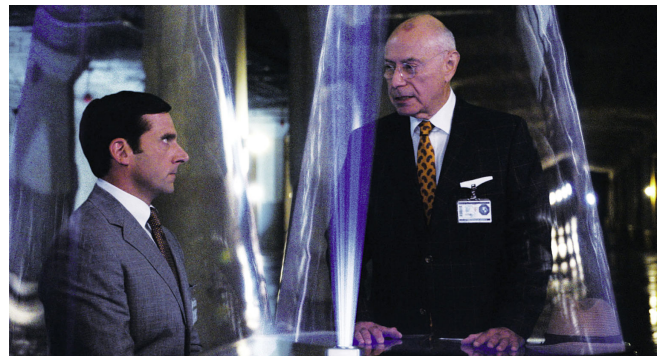
Steve Carell and Anne Hathaway star as agents Maxwell Smart and ‘99’ in director Peter Segal’s adaptation of the 1960s-era television comedy *Get Smart*, a spoof on the spy genre created by Mel Brooks and Buck Henry. The production featured an updated take on the ‘corridor of doors’ that opened each episode of the series as Max made his way to the headquarters of CONTROL, a top-secret branch of the U.S. intelligence service.

A misunderstanding aboard the plane leads to a sky marshal putting Max in handcuffs. Excusing himself to the lavatory, Max uses a special Swiss Army knife gadget — provided to him by CONTROL — to attempt an escape from the handcuffs. “This Swiss Army knife has all kinds of ridiculous functions, none of which is actually a knife. There is a blow torch on it, for example, and a tiny crossbow — and that is what Max uses to try to break open the handcuffs.” Special effects supervisor Michael Lantieri and his crew worked with the prop department to build multiple practical versions of a tiny working crossbow; but Rising Sun Pictures, led by visual effects supervisor Tony Clark, added digital arrows that shoot out of the device. “Max keeps missing, and so arrows are ricocheting around this tiny bathroom. One goes into his ear, another into his cheek — he gets about 15 of them stuck in him. Each arrow has a thread coming out of it, too, and they create this web around Max. Since Rising Sun had done the spider webs in *Charlotte’s Web*, we thought they were the logical place to go to for this scene. They helped choreograph the sequence, which was done as complete improv and then cut together. They really got all the web/thread dynamics to work, and it turned out to be one of the best sequences in the film.”

When Max finally frees himself from the cuffs, he and 99 jump out of the 767 and skydive into the Russian landscape. Production hired a skydiving company to shoot pieces of the action; and then the visual effects crew filled in the sequence with footage of actors on wires, shot on a rear projection setup in Montreal that made use of new technology. “We used a digital projection system, then played back the rear projection footage off of D5 tape. We had vertically stacked projectors situated about 110 feet from a 25x40-foot screen. We drew from the skydiving backgrounds for our RP backgrounds, so as we went from a wide shot with the actual skydivers to a tight shot with our actors, it was a seamless transition. All of this was color-corrected in real time, using a box called a ‘Luther,’ which Technicolor developed. We were shooting Panavision Genesis cameras with HD monitors — so we could look at the monitors and do real-time color correction, with no guessing. You have to work hard in a greenscreen situation to get the lighting through the hair



For the film, production designer Wynn Thomas designed a variety of doors, but built only a corridor floor and a section of bunker wall on stage at Warner Brothers. Production shot the actors walking through the set against greenscreen, and then Zoic Studios computer generated all of the opening and closing doors, enhancing the original door designs. Zoic also extended the bunker environment in CG, adding levels of concrete walls and flickering fluorescent lights.



At CONTROL, Max and the Chief (Alan Arkin) thwart KAOS eavesdropping by conversing within ‘cones of silence.’ To update the look of the recurring practical gag in the television series, Peter Segal and visual effects supervisor Joe Bauer engaged Digital Dimension to create digital cones and track them into edited plates. Digital Dimension worked off of Wynn Thomas’ design to produce an electronic, wine-glass-shaped projection — comprised of 2D and 3D elements — that encased the agents individually. Warping effects distorted characters and sets visible through the cones.

and the depth of field; and sometimes you nail it, and sometimes you don't. With the RP setup, we really got it. We wound up using the RP approach for about 150 shots throughout the film."

In Moscow, Max and 99 attend an upscale party as a means of obtaining important computer information. While exploring the premises, the agents come to a long hallway crisscrossed with motion-detection laser beams. Eden FX generated and composited digital laser beams and smoke for the sequence. "99 slides a gadget that looks like a compact across the floor. It shoots out smoke, which reveals this ornate web of lasers in the hallway. 99 does a very elegant, sexy move through the hallway, avoiding the laser beams; and then Max tries to copy her. To stand in for the laser beams and give the actors something physical to move around on the set, we set up yellow monofilament with magnets on the back so we could move the strings around and adjust the web of lasers. We hoped that Eden FX could just lay the laser effect on top of the strings;

but sometimes the actors hit the wires and made them sag, so they had to be painted out. Also, we decided to break up the beams. Eden ended up painting out every single string, in every frame of every shot. Then they did a great job of laying in this laser effect and digital smoke. The hallway looks really dangerous." Visual effects supervisor Fred Pienkos led the work at Eden FX.

While in Moscow, Max and 99 determine that a bakery is really a disguised KAOS nuclear weapons plant. When Max sets charges to cripple the operation, he and 99 are detected by KAOS agents and chased to the bakery rooftop. A fight ensues, ending with the collapse of the roof when the charges detonate. The rooftop sequence combined footage shot in three locations, one of them a huge rooftop set that filled the massive Stage 16 on the Warner Brothers lot. "The set represented the whole roof of this plant, in accurate scale. Michael Lantieri rigged explosions to go off on the set as the actors were performing the fight scene. He did an amazing job of creating huge explosions that were in proximity to the actors. They were big enough to blow your clothes and hair, and yet no one was in danger. I've never seen anything like it."

Mike Joyce and his crew at Cinema Production Services built a miniature version of the set specifically for the rooftop collapse. "At Mike Joyce's place, they built this collapsible 1/8-scale rooftop miniature, and we shot that overcranked. Then, after we saw the miniature footage, we worked with it in effects editorial and slowed it down another 30 or 40 percent." Amalgamated Pixels and Pixel Magic added a Moscow skyline to the live-action set fight shots, while Eric Chauvin of BlackPool Studios generated matte-painted backgrounds for the collapsing roof miniature photography.



On a mission in Moscow, Max attempts to traverse a long hallway protected by motiondetector laser beams. To stand in for the laser beams on the hallway set, the production ran yellow monofilament from wall to wall, providing Carell with a physical maze through which to make his labored, comedic passage. Eden FX then erased the monofilament lines and replaced them with digital beams. To render the beams visible, Eden also added digital smoke to the scene.

When Agent 23 (Dwayne Johnson) arrives in Moscow and finds no evidence of weapons manufacturing at the demolished bakery, he deduces that Max is working for KAOS. After subduing Max and transporting him back to Washington, the Chief, 99 and 23 carry him in a van to CONTROL, where he is incarcerated. Rear projection provided backgrounds for scenes of the characters driving around the capital.

Max is cleared of suspicion, and the story's action moves to Los Angeles, where the Chief and Max make a frantic drive to the airport to intercept a Cessna carrying KAOS agents. Michael Lantieri rigged special effects for shots of Max driving willy-nilly through a golf course. "The Chief and Max end up going across a golf driving range, and all the golfers start trying to hit the car. Michael had to find a way to launch thousands of golf balls the full distance of a driving range and really hit the car without hurting the car or the passengers, which was tricky. Then, Pixel Magic enhanced those shots with additional digital golf balls."

A ten-minute-long chase scene involving vehicles and the Cessna follows, culminating at Walt Disney Concert Hall in downtown L.A. "It's a race-against-time sort of sequence. They had trouble getting permission to fly a Cessna in certain areas of town, and so that became a combination of visual effects and practical special effects. Michael Lantieri put the husk of a Cessna on a rotisserie and other moving devices so we could get some in-camera stuff. Then we handed off from that to a digital Cessna." The digital Cessna was awarded to Digital Dimension.

Originally slated for 300 effects shots, *Get Smart* ultimately featured more than 800. The test — as with every comedy film — was the opposition of visual effects' need for pre-planning to comedic actors' need for an improvisational working environment. "On a comedy," concluded Joe Bauer, "it is always okay — even expected — to come up with new gags on the set and trash the ones you'd planned and prepped. That means you can only very generally plan how you're going to approach something in terms of the visual effects. Even though Pete Segal stayed close to the prep work we did, we still had to react to the improvisation that he encouraged throughout the shoot and to ideas that evolved during postproduction."

Get Smart photographs copyright © 2008 by Warner Brothers.



A climactic ten-minute chase sequence involving CONTROL agents in multiple vehicles and a Cessna carrying operatives from KAOS culminates at Walt Disney Concert Hall in Los Angeles. Due to flight restrictions in downtown L.A., the sequence combined practical and digital effects. Special effects supervisor Michael Lantieri mounted a Cessna mockup on gimbal rigs to enable production to capture some shots in-camera. Digital Dimension later created a digital aircraft for shots of the airborne Cessna and wide shots of the plane downed on location at Disney Hall.

Formula for a Universe

image

ARTICLE BY JOE FORDHAM

Tatsuo Yoshida's 1966 comic *Mahha Gô Gô Gô* and Fuji Television's animated spin-off spawned what, for many, became a seminal influence in the stylized world of 'manga' — Japanese for 'comics' — and its cel animation equivalent, 'anime.' Dubbed into fast-talking English and syndicated on U.S. television in 1968, *Speed Racer* fascinated young viewers with colorful adventures of racecar action and improbable gadgetry, despite the animation's limited technical resources.

The show gained a cult following, and rumors of a potential Hollywood live-action film adaptation began to surface in the early 1990s. Then, in 2006, producer Joel Silver and directors Larry and Andy Wachowski, creators of the *Matrix* trilogy, proposed a bold new take on the property to Warner Brothers.

The adaptation, written by the Wachowskis, would involve *Speed Racer* (Emile Hirsch), his car designer father Pops (John Goodman), Mom (Susan Sarandon) and girlfriend Trixie (Christina Ricci) as small-time operators of Racer Motors, threatened by the ruthless owner of Royalton Industries (Roger Allam). When Royalton attempts to run *Speed Racer* off the race circuit, the mysterious Racer X (Matthew Fox) coaches the young driver to battle Royalton's heavies through a succession of racing tournaments, a rally race and climactic Grand Prix.

The story became a launch pad for ideas that the Wachowskis developed with visual effects supervisors John Gaeta and Dan Glass, with whom they had collaborated on the *Matrix* trilogy. "We wanted to start anew," said Gaeta. "We wanted to put aside the dark dystopian aesthetic in *Matrix* and flip the polarity by going pop art and super optimistic. We called it 'poptimistic,' and that idea became a formula for the universe." Gaeta, Glass and the Wachowskis strove to create a visual vocabulary of live-action film techniques that captured the spirit of the 2D cartoon. "The brothers wanted to focus on the charm and inventiveness of the world that *Speed Racer* lived in. They wanted it to be a family-centric story. But they also wanted to stay true to the expressionist approach of anime."

Anime references included Katsuhiro Otomo's *Akira* and the films of Hayao Miyazaki, in particular *The Castle of Cagliostro*, a fanciful adventure that the Wachowskis' longtime conceptual designer Geof Darrow recommended as a favorite. "Cagliostro was a treasure of 'poptimistic' design," Gaeta noted. "It was exquisitely composed 2D animation. The camera perspectives, multi-planar layering, and the way the crazy, goofy events occurred were influential to us. For example, in chase scenes traveling hundreds of miles they created looping backgrounds. It was a standard convention of animation, but it was so well done in Miyazaki's film, it inspired a development path we called the 'conveyor belt.' We weren't trying to make a two-dimensional film, but we wanted to capture the nuances that created that feeling."

Gaeta and Glass developed concept tests with an in-house effects team known as Exhaust. The team, which included previsualization and visual effects artists from a variety of companies, ultimately generated several hundred shots in-house under visual effects supervisor Jake Morrison. Euisung Lee, previsualization supervisor at Halon, tested layering stock film footage in the style of 2D camera moves, separating background, midground and foreground layers with sliding perspectives. Digital artist Stephen Lawes, veteran of *Sky Captain*, explored techniques by manipulating storyboards in Adobe After Effects, creating looping backgrounds and deep-focus shots.

ILM generated tests of fully synthetic 3D environments with animated cars navigating wildly twisting racetracks. Evil Eye Pictures generated psychedelic glitter enhancements. And BUF Compagnie in Paris experimented with motion blur, stroboscopic effects and manipulating motion picture racing footage. “We asked BUF to experiment with shots from the James Garner racing movie *Grand Prix*,” recalled Dan Glass. “They took a shot of Toshiro Mifune, cut him from his background and created an orbiting CG camera move from him to James Garner. It created a strange elasticized motion. We called it the ‘nouveau pan’ because the French came up with it, and it introduced another field of experimentation.”

The team also experimented with ‘bubble’ technology, shooting photographic backgrounds as spherical panoramas. “We decided that photographic background bubbles would be analogous to the way anime used large painted backgrounds,” commented John Gaeta. “I suggested to Larry and Andy that *Quicktime* virtual reality photography might be a way to handle this. We’d shoot actors against greenscreen, then employ 360-degree photographic backgrounds to quickly create backdrops and mass-produce locations with pseudo camera moves.”

QTVR techniques had been in widespread use online, allowing viewers to navigate spheres of still imagery by manipulating cursors. To explore the technology’s cinematic potential, the production staged a shoot modeled after a scene in the film featuring Racer X reclining in a futuristic dwelling, discussing *Speed Racer*’s fate with a female friend. The scene was first realized by shooting 360-degree photographic backgrounds in a futuristic residence designed by architect John Lautner in Sunland, California. Digital Domain stitched plates into background bubbles, and director of photography David Tattersall shot actors in a greenscreen set utilizing a Sony CineAlta high-definition camera and a Codex Digital high-resolution media recording system to visualize background bubbles on set. “As images turned up on the Codex disc,” said Digital Domain visual effects supervisor Kim Libreri, “we could view them on a laptop on set and comp them immediately into our greenscreen. We shot image spheres for each character and wider angles for other shots. We keyed characters and digitally projected them onto cards so we could zoom and rotate around in this weird collaged world.”

Combined with a digital matte painting of a nighttime city outside the floor-to-ceiling windows, the test illustrated dramatic deep-focus compositions, shifting perspectives and parallax effects. “We were not trying to make it feel perfectly real,” observed visual effects supervisor Mohen Leo, who co-supervised with Libreri at Digital Domain. “We embraced the visual artifacts of the camera moving within the image sphere so the environments felt flat, like cartoon background paintings, but using real photography.”

The test was also a proving ground for the F23 camera, which the production selected after testing other state-of-the-art HD camera systems. “Shooting digitally allowed us instant access to images for visual effects,” said Glass. “Digital also gave us opportunities for color saturation and image clarity that had very relevant applications for a cartoon-inspired movie. We were not dismissing film. We wanted to present an alternative.” Digital Domain tested film grain looks by altering HD images. “We tested images side by side to show that we could approximate a film look through HD acquisition, but ultimately sought to create a new visual aesthetic. The directors were concerned with the unflattering way the HD clarity revealed skin pore detail. Film grain obscures textures so blemishes don’t read. We experimented with various techniques, and ultimately Pacific Title & Art Studio digital colorist Maxine Garvais, who oversaw our digital intermediate, came up with some creative techniques to ‘beautify’ our actors without making them look processed.”

To help choreograph actors in virtual environments, Digital Domain developed Sparky, an on-set visualization interface that used software written by programmer Brian Smith. “We used Sparky to shoot all our dialogue scenes,” explained Libreri. “It was an extremely valuable tool that we could use in real time to create compositions. David Tattersall could see where to place his key light, and what color the background and the foreground were going to be. He



Speed Racer (Emile Hirsch) pilots his Mach 6 racecar around Thunderhead Raceway in the film adaptation of Tatsuo Yoshida’s and Fuji Television’s colorful anime cartoon. The movie reunited writers and directors Larry and Andy Wachowski, creators of the Matrix trilogy, with visual effects supervisors John Gaeta and Dan Glass. The filmmakers strove to capture an anime feel using high-definition imagery of live performers, shot mostly against greenscreen, combined with digital animation and stylized compositing techniques executed by 14 visual effects vendors. Digital Domain generated the Thunderhead raceway, racecars and accoutrements as entirely synthetic creations.



For closeups and medium shots of spectators at the Thunderhead race, production designer Owen Paterson built a small section of the grandstands at Studio Babelsberg in Germany. The production then shot sections of the crowd against greenscreen, with crowd members dressed in iterations of the same brightly colored costumes. Digital Domain replicated the elements, deliberately repeating crowd arrangements and using step-frame cycling techniques to create animation loops reminiscent of the limited animation style of the original television cartoon. Exaggerated flashbulb pops, atmospheric lighting effects and a foreground greenscreen layer completed the scene.



could line up the greenscreen, set the characters, and then adjust his lighting, knowing exactly what it would look like later.”

Tattersall worked hand in hand with visual effects in a five-month greenscreen shoot at Studio Babelsberg in Potsdam, Germany. Simultaneously, production conducted an extensive location search for the film’s transcontinental rally race. The production’s environment plate supervisor, Dennis Martin, then traveled through Europe and North Africa shooting QTVR imagery, which he transmitted back to Germany via secure *Internet* connections.

Riding in a shiny purple jump-jet, Speed Racer and his family approach the city of Cosmopolis. The production developed studies of the city using futuristic architectural reference and conceptual art. BUF Compagnie generated Cosmopolis as a synthetic environment featuring 700 buildings built in the studio’s homegrown modeling and compositing software. BUF incorporated automotive shapes and fluorescent lighting into structures, modeled and lit each building in 3D, and then applied 2D treatments to create a colorful anime feel. Animators filled streets with cars and the skies with helicopters and blimps.

Martin and a small support team photographed spherical imagery using four Canon EOS-5Ds on a custom-engineered camera head, encoded with Digital Domain software. Martin’s team recorded spherical scenic vistas at extremely high resolutions, from 6K to 24K and above, occasionally making use of helicopter perspectives. For extreme high-altitude environments in the *Italian Alps*, the production hired Alex Golleger, a specialist QTVR photographer, to capture 360-degree imagery. Visual effects vendors then applied anime stylizations to those plates. “The locations had to look hyperreal,” stated Mohen Leo. “They picked the most beautiful picture of a mountain range, the most beautiful picture of a lake, the most beautiful picture of a forest, and then the vendors collaged them together like idealized post-card views.”

To shoot foreground elements of drivers at the wheels of vehicles, Effects in Motion supervisor Don Gray supplied a hydraulic motion base rig where actors could sit and interact as if jostled by the race. The rig made use of General Lift’s Encodacam motion recorders together with Kuper motion controls that moved data between camera, motion base and virtual car bodies. “The production gave us models of the 15 cars,” said General Lift founder Joe Lewis. “Bill Tondreau at Kuper Controls wrote some special software to give us accurate information of the virtual car position. That analog data went through an analog-to-digital converter to tell Kuper what to do with the motion platform. Kuper then sent analog information to the hydraulic platform, so its servo cylinders could move the rig. That motion sent information to Encodacam and our *Brainstorm* software, which showed us the position of the car. Another Kuper system brought data from the Technocrane on another channel. That gave us the camera view, so we could see what the car was doing in the virtual world.”

With additional software written by Pixel Liberation Front artist Andy Jones, the system allowed second unit director James McTeigue to shoot motion base race action with varieties of animation control. “We had animation export based on previz animation,” related Mohen Leo. “For more generic driving, we used *Image Space*’s driving simulator, rFactor. That drove the car around a 3D model of our racetrack and, in real time, could simulate all the bumps and jumps along the way, and play repeat takes. Then, for detailed interactions, we had a more free-form method of Waldo control.” The Wachowskis directed climactic race action and critical scenes with *Speed Racer*, using joystick controllers to hand-cue the motion base on set.

For scenes involving static racecars, production designer Owen Paterson commissioned custom car manufacturer TransFX to construct two full-scale props of *Speed Racer*'s sleek rocket-powered racing vehicle, the Mach 5, used for background dressing. All moving vehicles were digital. Eyetronics and Plowman Craven Associates supplied scans of 18 cockpit mockups and 30 race characters for use in generating digital versions of cars and drivers. In-house modeling supervisor Mike Meyers then worked with the art department to generate 60 digital cars, built in Maya for universal use among vendors. "It was a strategic collaboration," said John Gaeta. "We built all previsualization based on generic tools supplied by Digital Domain. They rigged the cars, and then we used those rigs to port over to vendors. We ended up with about 2,000 visual effects shots spread over 14 companies."

The movie's first race takes place at Thunderhead Raceway, a rugged circuit of metal loops, switchbacks and ramps surrounded by lights, bleachers and race meet set dressing. Geof Darrow designed the stadium based on the directors' brief. Owen Paterson's team built locker rooms and closeup portions of the stands as practical sets at Babelsberg, but Digital Domain generated the majority of structures, and all wide shots of the stadium, as synthetic environments.

The modular nature of the track allowed Digital Domain environment art director Jeff Julian and CG modeling supervisor Melanie Okamura to lay out a kit of stadium parts, augmented by custom pieces. Sequence supervisor Paul George Palop oversaw construction of Thunderhead structures to articulate the extreme combative nature of the motor sport. "We wanted racing scenes to be quite gladiatorial," said Gaeta. "We took our cue from the gizmo aspects of the *Speed Racer* series, where cars could jump and flip and drive on 90-degree surfaces. It was a more extreme version of the X Games, where contestants jump motorcycles 500-plus feet and do gymnastics before they land. We thought, 'Okay, if a bike can do that, how about a car with a small jet engine?'"



Speed Racer enters a Polynesian island race, the Fuji Helexicon, where drivers traverse an elevated raceway that snakes above tropical terrain. CafeFX handled the sequence, building island environments and digital matte paintings from stock photographic imagery of scenic textures and digital photography of Hawaiian and Southern Californian locales. Rugged island landscapes featured 3D models built with texture projections to simulate the effects of volcanic rock. Cars were adapted from digital models designed by the production, finessed and rigged at Digital Domain, and rendered with a high-gloss finish.

The Wachowskis named the racing style ‘Car Fu,’ which employed automotive gadgets from the original cartoon — including jumping jacks that sprang from beneath chassis to flip racecars through the air — and others invented for the film. *Speed Racer*’s Mach 5 was updated to ‘Mach 6’ for stadium racing and featured multiple foot pedals that allowed the driver to steer each wheel independently. “It was like playing an organ,” remarked Mohen Leo. “As Speed pressed the pedals, he could pivot each wheel in any direction and lift suspension to help him over curves. It was an important part of scenes where cars were doing spin-kicks and hits. The drivers needed that level of articulation to control the moves.”

Digital Domain animation supervisor Erik Gamache led performances of animated cars using a custom Maya setup to lend a semblance of real-world physics to vehicle motion, but the extreme nature of the racing action frequently required animators to override simulations. “Erik and his team would animate the racing line, and the car would follow that line,” said Kim Libreri. “The wheels would plant, the body would roll as it went into corners achieved through simulations — but our brief for each scene was so specific, we keyframed all the four-wheel steering. Car motion was never strictly tied to physics.”

Racecars were rigged to explode and tear apart at velocities between 200 and 300 miles per hour. “We built several cars for hero destruction,” related digital effects supervisor Johnny Gibson. “They had internal geometry and were pre-scored to tear apart dynamically so that when panels broke the machinery was revealed.” Explosions featured digital flame elements and debris, with special parameters controlling behavior of smoke and fire. “We put a lot of time into matching an anime style in our explosions. Digital Domain effects artists have had a lot of experience creating explosions in films like *Flags of Our Fathers*. This film used similar technology, but they reprogrammed the system to control the structure and timing of simulations, keeping edges from going too wispy and transparent. It made explosions feel more graphic.”

To render gleaming, multicolored cars reflecting the floodlit stadium, Digital Domain spent a year building a robust render pipeline in Mental Images’ Mental Ray and rendered race scenes using



Speed Racer’s advisor, the mysterious Racer X (Matthew Fox), narrowly avoids a fiery collision on the Fuji Helexicon raceway. Visual effects vendors designed explosions to emulate the 2D graphic flavor of the original Japanese comic and cartoon, controlling density and behavior of synthetic smoke and fire, and making sparing use of practical pyrotechnic elements in composites. CafeFX generated explosions in the Helexicon race by first exploring hand-drawn 2D pyrotechnics. When that concept proved too literal an interpretation, artists used 3D digital simulations.



In a sequence generated at Industrial Light & Magic, Racer X powers through the night on a lonely rural highway. ILM generated the highway sequence based on production animatics. The animatic employed scans of storyboards that were sliced into layers and then composited behind Racer X to create the impression of an endless rolling roadway. ILM translated the 2D cel-animation feel to the scene by combining scenic textures shot in Austria with 3D animated vehicles, and lined the road with a single tree, repeated endlessly.

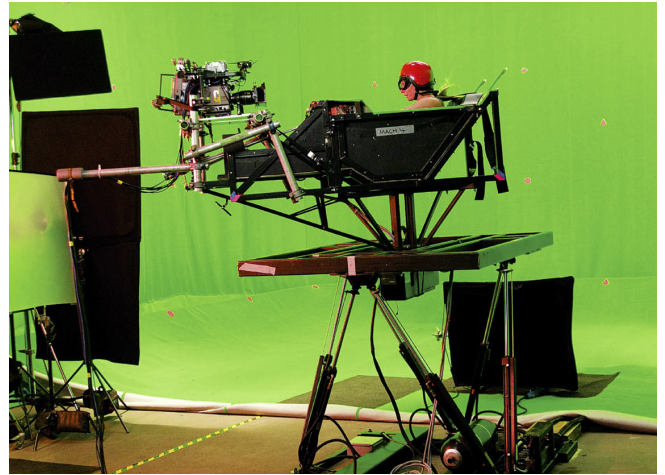
global illumination and multiple render passes. “It was ray-traced with pretty long renders,” commented Kim Libreri. “Some scenes required up to 16 gigabytes of RAM per render. We separated every object into keylights, environment lights, shadows and motion vectors. In compositing, digital effects supervisor Darren Poe dialed in the look and added motion blur; and if we wanted to make changes, we didn’t have to re-render the whole scene.”

Compositors also generated contrail-like streaks of light that hung behind vehicles in moments of high tension. “Graphic lines suggesting trajectory and energy were a device right out of manga,” said John Gaeta. “Through Darren Poe’s experimentation, they evolved into a very expressionistic technique.”

Digital Domain used Massive crowd simulations to populate 3D grandstands. Closer views of grandstands featured greenscreen crowd elements shot in Germany, replicated with stylized 2D compositing techniques. “They wanted crowd reactions to feel cartoony,” said Kim Libreri. “They shot a lot of individual greenscreen people, deliberately repeating costume colors. We then repeated patterns everywhere, skip-framed footage to produce staccato motions and added crazy flashbulb effects.”

After the Thunderhead tournament, the Racer family returns to its suburban home, one of the film’s few practical sets at Babelsberg. “Owen Paterson designed the Racer home as a practical build partly to reduce the visual effects toll,” said Dan Glass. “The directors also didn’t want the visuals to dominate the entire movie. The family story was very important to them, and they wanted a real set so those scenes would feel cozy and warm.” Racer home scenes made use of a portable greenscreen to assist splitscreen composites of anime-styled deep-focus shots, and to integrate performers with a pair of rambunctious live chimpanzees who portrayed the family pet, Chim Chim.

The family is interrupted when a Royalton Industries jump-jet lands on the front lawn. BUF generated the fanciful aircraft and subsequent effects when the Racer family visit the Royalton headquarters in the heart of a giant city, Cosmopolis. Geof Darrow created concept art of the city, and conceptual designer George Hull



To shoot closeups of drivers at the wheels of their vehicles, Effects in Motion supplied a hydraulic motion base rig that General Lift encoded to extract motion control data, allowing monitor views of performers in virtual cars. The production’s German stunt coordinator, Antje Rau, rides the rig in an early test shoot of the Mach 4 cockpit.



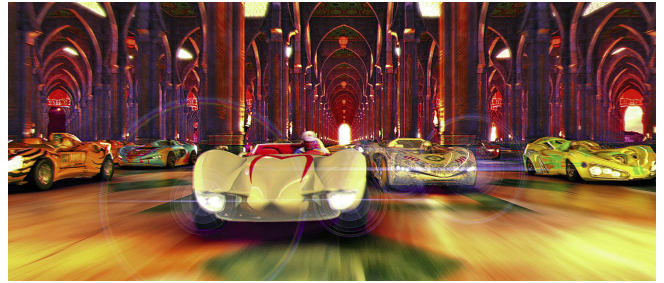
Speed Racer crests a sand dune flanked by competitors in the Casa Cristo Classic, a grueling international rally. BUF generated dune scenes using photographic plates shot in Namibia, enhanced with 3D dunes, 2D matte paintings, animated cars and digital dust and sand effects.

generated detailed studies of the enormous Royalton Industries building, combining 1960s futurist architecture, fluorescent lighting and car-like properties into buildings.

BUF generated Cosmopolis scenes in the studio's homegrown modeling and compositing software, without procedural automation. "We are old school," commented BUF president Pierre Buffin. "We built a city map and placed each building by hand to create naturalistic placements. Cosmopolis was similar in layout to Hong Kong, with developments around a bay. We built about 700 buildings, all modeled in 3D, then created layers for each shot and rendered them in 2D."

The hybrid 3D/2D approach allowed BUF to render city structures with correct lighting and shadows, and then apply 2D treatments to create a colorful anime look. "The production provided us with drawings of important buildings," explained BUF visual effects supervisor Geoffrey Niquet. "We built 26 for closeup work, and then added secondary buildings. We developed software to make camera moves in the city, and did placements in 2D. We then populated streets with cars and added helicopters and 15 varieties of blimps."

BUF generated the Royalton Industries building as a mammoth edifice extending a mile-and-a-half high, with architectural features resembling automobile engine parts detailed with myriad windows to create a sense of scale. *Inside* the building, Royalton takes Speed Racer on a tram ride, trying to impress the young man with operations on the factory floor. The Wachowskis filmed the tour with the camera peering into rooms containing bizarre activities, constructed from photographic material. "We visited a Volkswagen factory in Dresden and shot still photography of robots," noted Dan Glass. "We bought footage of a chimp in a training centrifuge from the film *Moonraker*. BUF then collaged those scenes into the rooms." Factory interiors included backgrounds populated with greenscreen elements of Royalton employees, looped to resemble anime motion cycles. For the main automobile manufacturing chamber, BUF referenced Geof Darrow conceptual art and created a multi-level production line populated with robots derived from Volkswagen factory textures.



Speed Racer leads a pack of rally cars in an early portion of the Casa Cristo Classic, navigating a labyrinth of giant arches through the market town of Muqrana. The production's environment plate supervisor, Dennis Martin, gathered photo textures for this and many other scenes, shooting high-resolution, 360-degree digital imagery in Morocco. BUF adapted and projected the textures onto the 3D geometry of Moorish arches, and layered the environment with 2D perspective effects.

Speed Racer chooses not to join Royalton's empire and later tangles with Royalton henchmen. ILM visual effects supervisor John Knoll handled effects for a sequence set on a rural highway where Racer X encounters a heavily fortified Royalton Industries tractor-trailer. The scene was one of the first storyboarded for the film, drawn by concept artist Steve Scroce. Stephen Lawes scanned Scroce's artwork, sliced imagery into layers and created a rolling road effect in After Effects, with columns of trees cycling behind vehicles. The animatic look became a template for the scene. "It was one of our best examples of a conveyor belt road," stated Dan Glass. "Dennis Martin photographed a road in Austria with mountains and waterfalls in areas clear of trees. ILM then took a single conifer, repeated it along the sides of the road and ran Racer X's car and the Royalton truck in between."

Undeterred by Royalton threats, *Speed Racer* throws himself into tournaments, including a Polynesian island race, the Fuji Helexicon. CafeFX handled the sequence late in postproduction, building the tropical locale mostly from whole cloth. “We had just three months for production,” related CafeFX visual effects supervisor John Van Vliet. “We quickly assembled a reference library and used that along with stock photos to build our matte paintings. Oddly enough, our greatest source of material came from my producer, David Van Dyke, who had been on vacation in Hawaii. David had flown over volcanoes and taken a lot of pictures with a high-end Olympus camera. Those proved to be incredibly valuable.”

The Fuji Helexicon featured an elevated raceway that snaked above tropical terrain with giant vertical loops and a ‘helexicon’ corkscrew. CafeFX conceptual artists Lei Jin and Minory Sasaki modified designs to create surfaces and supports that carried tracks above lagoons and molten lava beds. CG supervisor Todd Perry then coordinated assemblies of scenic background material, while digital artist Tran Mar generated 3D terrain using Adobe Mudbox. “We tried to emulate the old *Speed Racer* cartoon with a lot of 2D flats,” commented Van Vliet, “but we ended up using more 3D because the camera moves were so dynamic. Some of the terrains used texture projections, but a lot of it was 3D. Larry and Andy asked us to make the rock look like black anthracite coal; so as the camera moved around, it caught the light and looked pretty striking.”

CafeFX compositing lead Michael Cashore generated molten lava effects via 2D warping techniques in eyeon Fusion, creating the illusion of viscous liquid with glow and steam effects. For car impacts, effects animation artist Olek Lyzwanski created 3D digital explosions in Autodesk 3ds Max.

CafeFX modelers adapted racecars from Digital Domain models, and animation lead John Nguyen choreographed action to track geometry. Extreme action required careful nuancing. “Animators can sometimes make objects move too quickly,” noted Van Vliet, “so I was often telling them: ‘Slow it down. It doesn’t look like it has enough weight. It’s going to look too cartoony.’ But when I saw the rough cut, I said, ‘Put it back the way it was,’ because that was perfect for the movie.”

Compositors layered greenscreen motion-base elements of drivers into scenes with reflections projected onto vehicles, visors and windshields. CG lead Bryon Godwin oversaw the lighting and rendering, taking a cue from Digital Domain’s global illumination of glossy vehicle surfaces. “Kim Libreri was good enough to show us his recipe for reflections,” Van Vliet stated. “They had come up with what we called ‘100 coats of clear’ — it looked like somebody had taken a car, dipped it in lacquer 100 times and then buffed it. It had taken them a tremendous amount of time to derive that



Speed Racer and Sempre Fi-Ber use jumping jacks beneath their chassis to flip their racecars, as Thor-azine bears down on Taejo Togokahn. Sony Pictures Imageworks generated desert flats rally scenes using high-resolution, 360-degree digital imagery that the production shot in Death Valley. Imageworks projected control textures onto terrain geometry and used 3D shaders to simulate cracked mud, salt deposits and rocky surfaces. Cars were choreographed to deploy onboard weapons and defenses using mostly keyframe controls, and then were lit with highlights, reflections, glows and lens flares, all combined with stylized smoke and dust.

formula, stacking mattes in a particular way, and it saved us all that R&D, which was really helpful as we had so little time to complete our shots.”

Speed Racer next qualifies for the Casa Cristo Classic, an even more grueling tournament in which specially adapted cars embark on a two-day international road race that begins in Casa Cristo, a fictional North African coastal town loosely based on Casablanca. BUF created the environment from spherical production plates photographed in Morocco, and populated the sequence with 45 wildly customized rally cars. “The starting line was a mixture of Moroccan and Middle Eastern motifs,” noted BUF visual effects producer Simon Vanesse. “The cars started in a square with crowds on one side and a rocky promontory stretching out over the sea. To simulate the ocean, we did a 2D lighting effect and displacements on a photographic still. The crowds were 2D elements projected onto cards, with looping and sunlight effects.”

From production designs and models, the BUF team adapted nine hero cars, in addition to *Speed Racer*’s, and varieties of other vehicles with different textures, liveries and numerals. Cars first race through a sprawling covered marketplace, then a labyrinth of giant Moorish arches. “The arches were based on Moroccan photography projected onto 3D geometry, with 2D perspective effects,” said Geoffrey Niquet. “We integrated cars in 3D and applied camera movements with 2D treatments.” BUF created a custom dynamics tool that allowed animators to blend stylized racecar choreography with physics-based interactions. As cars collide, BUF generated smoke, sparks and flames to match car colors and animated manga-style explosions using photographic textures on 2D cards with 3D smoke and fluid simulations.

The race follows a desert track through dunes containing half-buried archeological artifacts. The production had planned to photograph scenic dune materials in Morocco, but instead licensed film footage shot in Namibia for Warner Brothers’ 10,000 B.C. BUF enhanced photographic elements with 3D dunes and 2D digital matte paintings, and animated cars with displacements on the desert road and swirls of dust and sand.

Emerging from the dunes, cars traverse desert flats while *Speed Racer*’s girlfriend, Trixie, follows in a helicopter overhead. Sony Pictures Imageworks generated the environment using spherical scenic plates that Dennis Martin photographed in Death Valley, California. “The previz came in a lot of different forms,” remarked Imageworks visual effects supervisor Kevin Mack. “Some shots specified a particular environment bubble. Others referred to directories of data. We had a ton of imagery, some high dynamic range, some super-high-rez and some just high-rez. In all cases, we split backgrounds into layers and did matte painting and multiplaning 3D effects in the anime style.”

Stylization required a saturated color palette. “The color design was the most exciting part of the project for me,” admitted Mack. “I make my own abstract fine art, so I’m very interested in the neurological effects of color. I have a theory that blue and orange is the most satisfying color combination because, for eons, people have been waking to see that hot sun in the sky, realizing they have survived another night. That’s why, in the desert race, the yellow/orange terrain and blue/purple sky felt so primal and alive.”

Imageworks digital effects supervisor Peter Nofz saturated colors by generating holdout mattes for specific areas of the image. For desert terrain, CG supervisor Dan Eaton projected control textures onto geometry rendered with 3D shaders representing cracked dry mud, salt deposits and rocky

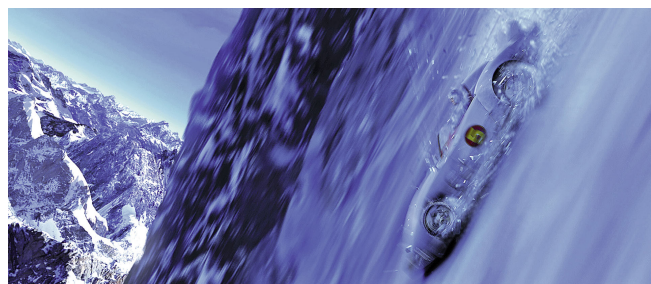
surfaces. Imageworks modelers adapted vehicles from Digital Domain and BUF geometry using custom textures and shaders, and lit cars with highlights, reflections, golden glows and lens flares. Imageworks animation supervisor Marco Marengi oversaw choreography of cars deploying onboard weapons and defenses using mostly keyframe controls. Effects animation supervisor Patrick Witting used fluid simulations to generate stylized smoke and dust trails.

After the desert race, contestants rest in Cortega, a fictional *Italian* village. BUF generated the environment from spherical scenic material shot in Siena, San Gimignano and Lake Como. Ninja assassins attack *Speed Racer* in his hotel room, filmed on sets in Germany using wire rigging to aid stunt performers. Pacific Title applied digital rig removals and enhancements, and Film Roman Media added anime-style graphics to fighting shots.

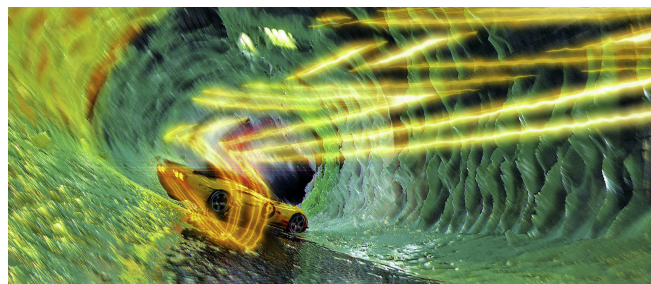
The race continues along alpine mountain roads with hairpin bends and switchbacks. Imageworks generated the environments using spherical scenic material with 2D and 3D imaging techniques. “We had some big camera moves, so we wound up using quite a bit of 3D,” stated Kevin Mack. “We projected our extensively painted photographic material onto geometry and generated full 3D elements with all the camera moves created in CG.”

In higher altitudes, cars encounter snow and spin off-road, leading to a fistfight between *Speed Racer* and Royalton thugs. The production shot the snow fight on a greenscreen stage in Germany, with no snow on set. In-house digital matte specialist Lubo Hristov painted spherical mapped environments and Evil Eye Pictures animated drifting snowflakes. The sequence segued into additional alpine race work, overseen by Imageworks CG supervisors Theo Bialek and Patrick Cohen, with cars skidding around icy roads, leading to the crash of *Speed Racer*’s main nemesis, Snake Oiler (Christian Oliver), whose vehicle was rigged for destruction with digital smoke and flame effects. Cars also race through darkened ice caves. BUF generated the race through a network of cylindrical tunnels with highly reflective surfaces bouncing light, sparks and shadows around cars, rendered entirely with ray-tracing.

The rally concludes in Berlin, with surviving vehicles passing triumphantly through a pair of arches generated at BUF from photographic textures of the Brandenburg Gate. “BUF made two massive Brandenburg gates,” said John Gaeta, “duplicating the original and having one face the other. They also built grandstands and assembled the environment with photographic components, mixed with a lot of



The second leg of the Casa Cristo Classic leads drivers into perilous alpine country, where Snake Oiler forces *Speed Racer* over an almost vertical ice wall. Imageworks generated the scene and *Speed Racer*’s hair-raising descent by sampling the production’s digital photographic scenic elements, shot in Italy, to build a multi-layered digital matte painting of the mountainside. Imageworks then projected textures onto 3D geometry.



As the Casa Cristo alpine run continues, Racer X careens through darkened ice tunnels known as the Maltese Ice Caves, which BUF generated as a completely synthetic environment. BUF constructed tunnels as a network of rough-hewn cylinders, with special emphasis on lighting as colored lights from the speeding racecars illuminate the highly reflective surfaces to stroboscopic effect. BUF artists

3D.” The Brandenburg finale included an homage to the TV series title sequence in which *Speed Racer* leaps from his Mach 5 and freezes, the camera circumnavigating him as orange and yellow checks appear behind him.

Speed Racer returns to Cosmopolis, where race drivers gather in a Grand Prix stadium designed to test the limits of their skills. Digital Domain sequence supervisors Richard Morton and Haarm-Pieter Duiker filled the giant arena with daunting obstacles — jumps, a half-pipe with giant deadly spikes, and a corkscrew spiral — and populated grandstands with approximately 2.5 million spectators. The vast numbers required an addition to Massive and 2D crowd replication. “In our wider shots,” remarked Kim Libreri, “wherever it was not possible to tell if characters in the crowd had limbs, we used what we called ‘Terrance and Phillip’ models — named after characters in the TV show *South Park*. They were literally circles on cards. But it worked!”

For an earlier establishing shot of the race venue, Digital Domain supplied a stadium model to BUF, which integrated the structure into its Cosmopolis environment. For views inside the stadium, BUF generated a 22K digital cyclorama of the city structures with buildings projected inside a cylinder, built in three layers to create parallax effects.

The climax of the Grand Prix — a contest between *Speed Racer* and Cannonball Taylor — involved an intense flurry of digital psychedelia featuring color treatments and optical artifacts developed by Darren Poe as a library of effects in NUKE known as ‘bling.’ “Digital Domain cooked up every form of glitter and light streak imaginable,” asserted John Gaeta. “It was the stylistic equivalent to an *Independence Day* firework finale.”

After a miraculous win, *Speed Racer* is surrounded by a barrage of popping flashbulbs. CIS Hollywood generated effects amid spherically mapped bubble imagery. “We created stylized lens flares for sequins on women’s clothing and jewelry,” stated CIS visual effects supervisor Bryan Hirota. “We added so many flashbulb blings, the crowd was barely visible and the stands became a sea of stylized flashes. We added multicolored fireworks bursting overhead using digitally treated elements of real fireworks. And then, when Speed and Trixie share their one and only kiss in the film, all the flashbulb flares turned into heart-shaped blings.”

The intense, experimental work on *Speed Racer* required uncommon artistic contributions from all the visual effects vendors involved; and the film’s unique look ultimately required a rethinking of the role of visual effects in the production process. “It was all about creating an end-to-end

rendered surfaces with ray tracing, bouncing reflections of lights, sparks and shadows around cars, and applied barrier at the film’s climactic Grand Prix. Digital Domain handled the Grand Prix sequence, constructing a giant arena containing 2.5 million spectators. The raceway featured multiple configurations that tested contestants to the limits of their endurance. The zebra-pattern barriers contained successive poses of a running zebra that, when viewed from passing vehicles, appeared to gallop along beside the raceway — an homage to Eadweard Muybridge, an early pioneer of animal motion photography.



Approaching the Grand Prix finish line, drivers navigate a tunnel of lights and motion graphics — known as Electric Corridor — where *Speed Racer*’s Mach 6 blasts through an explosion created by the collision of two rivals. Digital Domain generated the environment and an animated checkerboard tunnel that forms around the Mach 6. To realize the explosion and debris, artists used a combination of photographic plates and digital effects elements projected onto multiple 2D cards that were layered in 3D space, creating a multiplaning anime look as *Speed Racer* and his car burst through the fireball.

approach to making a movie,” concluded John Gaeta. “The visual ideas were rooted in animation techniques from 40 or 50 years ago, albeit applied to contemporary digital cinema tools. It was a heavy incubation period, but then we took those concepts and pushed them out there to give them life and create images. That was the goal. We gave everybody the flexibility to solve the problems in an expressive way, as opposed to a photorealistic way.”

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Tha Man in the Iran Mask

image

ARTICLE BY JODY DUNCAN

When Industrial Light & Magic visual effects supervisor Ben Snow wandered into the office shared by viewpoint artist Ron Woodall and modeling supervisor Bruce Holcomb to mention that ILM was considering doing a test for an *Iron Man* film, he was unprepared for the intensity of their response. “Both Ron and Bruce leapt out of their seats and hit the roof and started laughing,” Snow recalled. “It turned out that they were both huge *Iron Man* fans. They had *Iron Man* screensavers on their computers; and they had even worked on a small *Iron Man* project of their own, with storyboards and everything. They said they’d work after hours to build an *Iron Man* model so we could do this test; and that helped convince ILM to do it. There was a lot of enthusiasm for the project, and that really buoyed the whole production.”

Driving that enthusiasm was a conviction that *Iron Man* was destined to be a special project — for many reasons. The effects would be supervised on the production side by John Nelson, an Academy Award winner for *Gladiator* and an ILM alum. It would be the most ambitious film ever helmed by Jon Favreau, a director whose previous films, though more modest in scale, had demonstrated a strong narrative sense and a deft comedic touch. Robert Downey Jr., an Oscar-nominated actor of inestimable charm, humor and gravitas, would play the title role. *Iron Man* would also have the distinction of being the debut film from the new Marvel Studios — formed after the comic powerhouse had reacquired the rights to its previously optioned properties — and potentially the launch of a blockbuster film franchise.

Though mainstream pop culture had never embraced *Iron Man* to the extent it did *Spider-Man* and other Marvel superheroes, the character had inspired fierce loyalty and admiration within the comic book fan base. As introduced in 1963, in a story written by Stan Lee and illustrated by Don Heck, Tony Stark is a brilliant weapons inventor and manufacturer, a millionaire playboy and inveterate drinker. Wounded and captured in the jungles of Vietnam during the U.S. conflict there, Stark is commanded by his captors to build a bomb from materials they have gathered. *Instead*, he builds a suit of iron equipped with miniature transistor technology that protects his heart, weakened from embedded shrapnel, and enables him to escape. Stark returns home a changed man who, as *Iron Man*, protects and avenges those put in harm’s way when his Stark Industries weapons fall into the wrong hands.

Iron Man was in film development limbo for a number of years, bouncing from one studio to another, with various directors attached. When Marvel finally reacquired the rights to the property, executive Avi Arad approached Jon Favreau about developing the project from scratch. “It was nice to develop it with Marvel,” said Favreau, “because they have a different view towards the source material than the studios do. Studios tend to see source material only for how it can benefit them. They tend not to stay true to it or be protective of it. But these properties are Marvel’s bread and

butter; and so they don't want to do anything to diminish them. A studio would say: 'Who cares? Let's just get it on the screen.' But Marvel wanted to do it right."

Favreau worked with screenwriters Mark Fergus, Hawk Ostby, Art Marcum and Matt Holloway to update the original comic book story, taking it out of the Vietnam era and into the present day. The screenwriters also gave the story a major technological overhaul, replacing the 'miniaturized transistors' of the comic book with high-tech 'repulsor technology' and 'arc reactors.' "The technology changed a lot," observed Favreau. "It had to. The original *Iron Man* suit in the comics had roller skates that popped out! We had to come up with technology that would play with a much more discerning audience — without violating the expectations of people who grew up loving *Iron Man*."

Favreau and his collaborators were also diligent about maintaining the irreverent tone of the Marvel Comics, in general, and the antihero qualities of Tony Stark, in particular. "There was always a lot of attitude in Marvel characters," noted Favreau, "which was a reaction to DC and the more mainstream comics. DC's heroes were very iconic and earnest; but Marvel was more about attitude and making the unexpected choice. Marvel had heroes who couldn't pay their rent, or who bickered and couldn't get along. In the case of Tony Stark, he was a weapons designer at the beginning of the Vietnam conflict — not the most popular character of his day. We wanted to maintain that and bring the Marvel style of humor to the film, but still deliver the level of spectacle that people expect from these types of films."

A substantial storyboarding and previz effort contributed to the development of spectacle and storyline. John Nelson's first order of business, upon coming on the show in August 2006, was to hire Pixel Liberation Front — led by Kent Seki — to begin previzing shots with Favreau at Marvel's Beverly Hills headquarters. The production team also engaged what Nelson dubbed the 'New York Yankees of storyboard artists.' "We had Dave Lowery, Steven Platt, Eric Ramsey and Phil Keller doing boards while Phil Saunders was designing *Iron Man* suits," stated Nelson. "We also had Ryan Meinerding doing concepts that were out of this world. We sort of gene-spliced the storyboard people with the previz team; and so we had them all working together, boarding and previzing the large action sequences. Production also hired Jim Rothwell to do animatics. He would do a kind of anime treatment, rotoing elements from the storyboards and doing 2D moves on them."

As the previz and boarding continued, production commissioned *Iron Man* test shots from eight major effects vendors. John Nelson and visual effects producer Victoria Alonso awarded ILM nearly 400 shots, most of which involved a computer generated *Iron Man*. Nelson and Alonso awarded The Orphanage another 150-plus shots, including several CG *Iron Man* shots, graphics displays representing the virtual environment within *Iron Man*'s helmet, a weapons test sequence and shots of the Stark jet. *Iron Man* represented the first feature film assignment for The Embassy, a small effects facility in Vancouver that Nelson engaged to produce CG shots of a crude *Iron Man* suit Tony Stark builds to escape captivity. Later in postproduction, Lola Visual Effects produced digital vein effects; Prologue produced hologram effects and graphic screens in Stark's high-tech mansion; and CafeFX contributed digital matte paintings.

Jon Favreau's brief to John Nelson and the visual effects vendors was that this superhero movie would not feature spectacle for spectacle's sake, and that flawless photorealism would be the standard. "I wanted the effects to be an exciting element of the movie," stated Favreau, "but I made every effort to integrate the effects into the reality of the story. A lot of superhero movies lose sight of the fact that they have to keep things photoreal — because the less real the action is, the more you subconsciously detach yourself emotionally from the story. Movies are an emotional medium, and when you create a layer of artifice between you and the audience, you lose the connection with that. So maintaining realism was an overall strategy that we stayed true to throughout the making of this movie. To do that required a real partnership between the director of photography, Matt Libatique, our production designer, J. Michael Riva, John Nelson and Victoria Alonso, the second unit director, Phil Neilson, Marvel, the effects vendors and myself."

The commitment to photorealism in the effects work, specifically, meant doing whatever was necessary to take the digital 'curse' off computer generated characters and environments. "I constantly asked myself, 'What would it really be like to photograph this if it was a real event?'" Favreau commented. "Sometimes you miss a bit of action. Sometimes you don't frame it properly and the camera lags behind. We would make things look practical by not having everything in focus, not always having the right lens or having the camera in the right place. We also made the lighting in the plates a bit imperfect, letting elements blow out or fall off. All of those little things had the cumulative effect of making you feel as if you were witnessing something real, rather than CG."

An outspoken critic of the overuse of CG in films, and a fan of old-school, practical effects, Favreau had nonetheless reconciled himself to the fact that, due to the physical nature of the character and his super-powers, *Iron Man* would have to be computer generated in a significant percentage of shots. Even so, the filmmaker recognized the value of having real *Iron Man* suits on the set, worn by Robert Downey Jr. or stunt doubles. The on-set suits would enable Favreau to capture some practical shots — thus alleviating the CG burden — and, if nothing else, would provide the digital effects teams with invaluable lighting reference.



Marvel Comics formed Marvel Studios to develop feature films from its comic book properties, and chose as its debut production *Iron Man*, based on a character introduced in the 1960s. Directed by Jon Favreau, the film stars Robert Downey Jr. as billionaire weapons designer Tony Stark, who is wounded and captured by insurgents in Afghanistan. Commanded by his captors to build a missile, Stark instead uses the materials to construct a metal suit that protects his damaged heart and enables him to escape. Upon his return home, Stark refines his suit design and emerges as Iron Man, nemesis of militants around the globe.



With the U.S. military in Afghanistan, Stark demonstrates his company's powerful new 'Jericho' missile, which — once launched — divides into multiple lethal projectiles that strike and level a mountain range. Production visual effects supervisor John Nelson awarded the sequence to *The Orphanage*, which integrated CG missiles with practical pyrotechnic effects orchestrated by special effects supervisor Dan Sudick. *The Orphanage* also embellished

the live explosions with digital elements and obliterated the mountains via a CG shockwave effect.

Production engaged Stan Winston Studio to create the suits, a project supervised by Shane Mahan.

“Shane, Victoria and I went through the storyboards

and figured out what we could do practically, and what we would do in CG,” related John Nelson.

“There were obvious places that were going to be CG, obvious places that were going to be practical — and then there were shots that could go either way. We just went in with the attitude that we would get as much as we could with the practical suits; and we ended up with some very nice practical shots in the movie.”

Three versions of the *Iron Man* suit would be featured in the film: the ‘Mark 1’ that Stark builds in captivity; the silver ‘Mark 2’ he builds when he returns to his home workshop; and the red-and-gold ‘Mark 3’ — the ultimate in *Iron Man* engineering. Phil Saunders and Ryan Meinerding spent much of the preproduction period designing the suits, inspired by the *Iron Man* character as drawn by Marvel illustrator Adi Granov for the recent ‘Extremis’ series of comic books.

Stan Winston Studio translated the 2D concepts into something that would work in the real world.

“Up to that point,” explained Shane Mahan, “there were designs for separate elements of the suit — this back, these feet, that chest, that head. We had to massage all of those different pieces into a whole that made sense. Also, all of the illustrations up to that point were comic-book-style illustrations. They looked fantastic, but they wouldn’t necessarily work in the real world. We still wanted to pay tribute to the comics; but, while doing that, our designers had to make the suit function, to make sure that the joints worked and that pieces wouldn’t crash into one another.”

Winston digital artists first sculpted suit pieces in the computer to allow for virtual motion tests.

“That allowed us to see what parts of the suit were going to crash,” said Mahan. “It told us how much rotation we were going to get in the elbows and other areas. It also helped us to figure out the ideal proportions for the suit. Jon Favreau felt that *Iron Man* should be six-foot-five, because at that height, the suit looked really dynamic.” The suits had to be retrofit somewhat once Robert Downey Jr. was cast, to ensure the actor would fit inside. “This wasn’t done in the traditional manner, where you’ve got Christian Bale as *Batman*, so you do a body cast of Christian Bale, and you sculpt the suit on top of that, and you know the actor will fit in there. This time, we had to design the suit first, and then figure out how to get Robert Downey Jr. to fit inside. Of course, Robert isn’t six-foot-five; but the idea was that we would put him in the suit from the thighs up, with the additional height in the lower legs.”

Once designs were approved, Mahan and his team moved into suit construction. The build list included two complete Mark 1s, plus parts; one Mark 2; and two hero Mark 3s. “The challenge was that these were all hard, exoskeleton suits,” observed Mahan. “It wasn’t like a *Batman* suit made out of soft rubbers, or *Spider-Man*’s flexible, action-friendly suit. This was like building a fighter jet.” The team fabricated hard shells out of composite epoxy, glass and metal, and constructed areas requiring more mobility — such as the neck, elbows and torso — out of urethanes painted to look like metal. Early on, the production team had considered using greenscreen material in such areas, then tracking in digital suit pieces in postproduction. Winston Studio tested the idea and made some progress; but production soon realized that such an approach — requiring digital effects for virtually every shot of *Iron Man* — would be cost-prohibitive.

Finding a urethane and paint combination that would simulate metal required exhaustive research. “We finally found a company in Switzerland that could create custom mixes and bake out pieces with durable urethane paints,” said Mahan. “That solved the problem, and we were able to fill in the elbow, knee, neck and abdomen areas with semi-flexible material that allowed him to twist and bend without a lot of funny buckling and wrinkling.” Devising final paint schemes for the suits also involved trial and error, particularly for the Mark 3. The Winston team, with production, shot three separate screen tests with 15 different combinations of reds and golds before finding two complementary tones.

Final Mark 2 and 3 suits were made up of about 70 separate pieces, while the Mark 1 was comprised of more than 100 parts, all assembled to ensure no seams or fastenings would be visible to the camera. Weights ranged from a full 90 pounds for the Mark 1 to about 40 pounds for the sleeker Mark 3. The Winston team also built a variety of urethane stunt suits, enabling the filmmakers to capture a wider



Though production planned to rely heavily on computer generated imagery for shots of Iron Man and Iron Monger — the latter the alter-ego of Stark Industries executive Obadiah Stane — the filmmakers enlisted Stan Winston Studio to build practical versions of the characters, both as maquettes and in full scale. Full-size suits on set provided lighting reference and enabled Jon Favreau to capture some shots in-camera. Favreau, producer Peter Billingsley and Winston Studio supervisor Shane Mahan examine the Iron Monger maquette.



range of physical actions than what could be performed in the heavy and restricting hero suits.

Mahan and Winston crewmembers Eric Tucker and Dave Merritt at work on the Mark 1 suit in which Stark escapes captivity.

Stan Winston Studio also built a partial suit for the character of Iron Monger, *Iron Man*'s principal adversary in the film. Ryan Meinerding had developed Iron Monger concepts; but, again, Mahan and his team had to tweak the 2D designs to translate them to the real world. Though the Iron Monger suit was originally intended to serve only as a poseable lighting stand-in, Mahan's team built it with movable joints and hips that could swivel, so that it might be used as an articulated puppet on set. "I knew that once we got on set, having an Iron Monger puppet would help them," said Mahan. "Even if it only allowed them to get one or two shots, that was still two shots they didn't have to worry about after the fact. My intention was to help John Nelson in any way possible." To facilitate on-set mobility, the Winston team designed a pneumatically supported, wheeled gimbal rig on which the upper half of Monger's massive body could be mounted and moved around stage. Dan Sudick's special effects team welded the rig together, based on the Winston design, just prior to the start of filming. The rig was either painted out digitally in postproduction, or was framed out of shot.

In addition to full *Iron Man* and Iron Monger suits, Winston Studio built individual mechanical props such as *Iron Man*'s flight boots, arm thrusters and hand controls. For a scene in which Stark's assistant, Pepper Potts (Gwyneth Paltrow), makes repairs on her boss' mechanically-assisted heart, the crew built a replica of Downey's torso for a traditional slant-board gag. "We did lifecasts of Robert in various poses," said Mahan, "as well as scans, and then we built this chest with a deep cavity where the heart would be. It was made of silicone, and it had breathing bladders and punched hair. It turned out really well."

The Winston crew arrived on set with its array of practical suits and paraphernalia when principal photography commenced in February 2007, on stages at Playa Vista — ironically, once an aviation



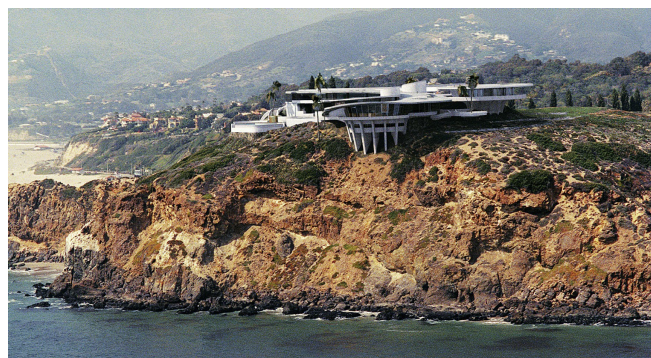
Encased in armor and with flamethrowers blazing, Stark emerges from an Afghanistan cave. The Winston Studio translated 2D Mark 1 concepts into a 3D computer model, and then fabricated the suit out of composite epoxy, glass and metal. Major joint areas requiring mobility were made of urethane painted to simulate metal.



For shots that could not be obtained with a performer in the restrictive suit, The Embassy created a computer generated Iron Man, using digital photographs of the practical Mark 1 – which featured hundreds of rivets, welding seams and other fine details – to texture the model and ensure an exact match.

assembly plant owned by Howard Hughes, the man on whom *Iron Man* creators Stan Lee and Jack Kirby had originally based the character of Tony Stark. Production moved on to other locations in and around Los Angeles, then to the desert and mountains near Lone Pine, California. Second unit ran simultaneously to first unit, with visual effects supervisor Wes Sewell overseeing effects concerns on second unit stages and locations. The shoot ended in June 2007, but the effects team continued shooting motion capture material of stuntmen for *Iron Man* shots well into postproduction.

The film opens in Afghanistan, where a military convoy transports Tony Stark from a site where he has demonstrated — to devastating effect — a powerful new Stark Industries missile, the ‘Jericho.’ En route from the test, Stark is wounded in an insurgent attack. Production shot the sequence near Lone Pine, capturing large-scale pyrotechnic gags in-camera. The story then flashes back to 36 hours earlier and a scene in Las Vegas that establishes Stark’s character as a high-rolling gambler and womanizer. The action picks up the following morning at his home north of Los Angeles, where Christine Everhart (Leslie Bibb), a reporter he has bedded the night before, stands gazing out the floor-to-ceiling windows as the camera pulls back to reveal the ultra-modern mansion sitting on a cliff overlooking the ocean below.



Having escaped his captors, Stark returns to his ultra-modern dwelling. Stark’s homestead was a composite of an aerial plate shot by John Nelson over Point Dume State Park in Malibu and a digimatte mansion created and tracked into the plate by Industrial Light & Magic. Although Jon Favreau – a fan of old-school effects techniques – considered realizing the house as a miniature, the digimatte approach afforded him the flexibility to tweak the building’s design well into postproduction. ILM fully detailed the synthetic house interior to accommodate a full range of camera angles and proximities.

John Nelson shot the aerial plate for the pullback — with aerial director of photography David Nowell and aerial coordinator Kevin LaRosa — at Malibu’s Point Dume, a state park overlooking Santa Monica Bay. “There is no house there, really,” said Nelson, “so ILM had to add it. It is very impressive and detailed — even to the point where, if you look in the windows, you can see that the bed is made in the spare room! Early on, we were thinking of doing the house as a miniature; but I realized pretty quickly that it needed to be CG, mainly because we were still designing the house, and we wanted the flexibility to make changes as the design evolved.”

On the set, the camera pulled back from the actress as far as was physically possible. ILM digital matte supervisor Chris Stoski re-created the room digitally to maintain perspective and continued the pullback to reveal the entire expanse of the digimatte house exterior. ILM added CG ocean to the Point Dume plate to further extend the pullback.

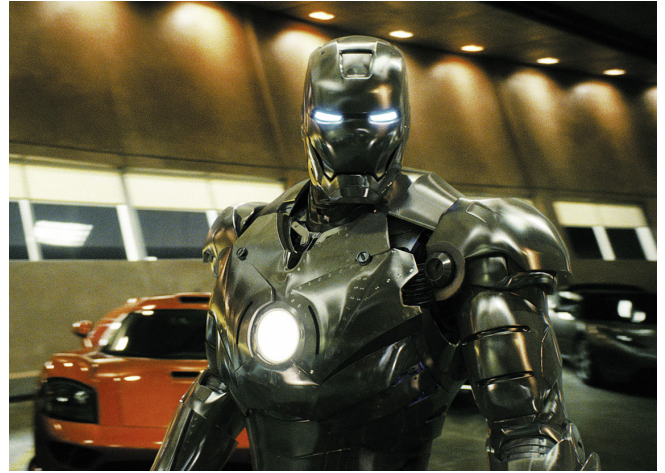
The flashback continues with Stark’s arrival in Afghanistan and the Jericho demonstration, live-action plates for which were shot in the Alabama Hills near Lone Pine. The Orphanage created the launching CG missiles, which spew dozens of multiple warheads that strike the mountain range with tremendous force. The CG destruction was integrated with live pyrotechnics. “The Alabama Hills is a protected area,” noted Nelson, “so we couldn’t set off any pyro there. Lucky for us, we

found a range near Los Angeles that was about one-third smaller, but looked very similar. So we were able to do some practical explosions there, which The Orphanage then heavily augmented. They embellished the explosions and used CG elements to create a shockwave that destroys the mountain range.”

The story flashes forward to Stark’s awakening in the insurgents’ cave, where his fellow captive, Yinsen (Shaun Toub), has saved his life by inserting a battery-powered magnet in his chest that prevents shrapnel from entering his heart. Presented with high-tech materials from which his captors demand he assemble a Jericho missile, Stark instead fashions a miniature arc reactor to replace the crude chest magnet and power a suit of armor, the Mark 1, in which he will make his escape. Though the Mark 1 — detailed with rivets, hoses, cylinders and other industrial detritus — was the heaviest of the *Iron Man* suits and the most difficult to wear for long periods of time, production was able to capture much of the escape sequence in-camera.

The Embassy created a CG Mark 1 for shots that could not be obtained practically. The Embassy visual effects supervisor Winston Helgason was on the cave set in Playa Vista, and also accompanied production to Lone Pine for exterior shots. “The first thing they shot for this,” related Helgason, “was *Iron Man* breaking out of the cave, and then going outside and flame-throwing everybody. The suit looked so great and performed so well for all of that, I remember thinking, ‘Wow, I don’t even know how many shots we’re going to wind up with here!’ But once they cut everything together in editorial, they realized they needed more *Iron Man* action. The practical suit didn’t allow the actor to fall down, to crouch, to walk downhill — there were a number of limitations to what a person could do in the practical suit, and that’s where we came in.”

To model the Mark 1, The Embassy started with a Gentle Giant scan of the practical suit, which provided the basic digital geometry. Gentle Giant also did some additional computer modeling by hand to create detail not captured in the scan. Scan data, CG models and pieces of the practical suit were then sent to Vancouver, where The Embassy CG team — headed by Michael Blackbourn, Paul Copeland and Simon van de Lagemaat — spent several months remodeling and texturing the CG character. “I took a ton of digital stills on set for texturing,” said Helgason. “We also put pieces of the suit in a light box so we could light them evenly and pull really high-rez textures off of them.” Paul Copeland painted textures on the model in either Pixologic’s Zbrush or Luxology’s Modo, the latter a recently released modeling and texturing program that The Embassy — one of the program’s original beta testers — had been using for two years. “Modo and Zbrush were great for all of the very detailed rivets and welding seams that were on the Mark 1.”



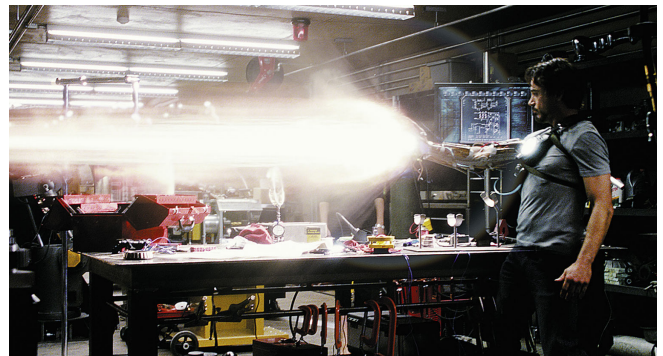
Stark’s refinements to the Mark 1 suit design result in the more technically advanced and aesthetically appealing Mark 2. Though ILM had two decades’ worth of experience creating spaceships, robots, droids and vehicles in CG, the Mark 2’s highly reflective surface and its proximity to camera in many shots made it the most challenging synthetic metal character in the company’s history. Judging the surface of the practical suit too shiny to allow for standard laser scanning, ILM used photogrammetry techniques to model the Mark 2.

Most of The Embassy *Iron Man* shots made use of motion capture recorded by Giant Studios on stage at Playa Vista, with stuntman Mike Justus wearing a vest to keep his spine Iron-Man-straight. For a shot early in the escape sequence, Jon Favreau performed the motion capture moves himself. “*Iron Man* bursts out of the cave,” said Helgason, “does a huge right hook cross on a guy shooting at him, sends the guy flying, then rights himself. Since it is one of the opening shots of *Iron Man*, it had to be a big, super high-rez, heroic establishing shot. Jon Favreau was very specific about how the motion should be; and, finally, he went into the motion capture studio, got suited up, and did the move himself. Then that motion capture data came up to Vancouver to be cleaned up.” When Favreau decided he wanted to push in on the static shot, The Embassy had to scan the original plate at a higher resolution, render its CG *Iron Man* at 4K, and then execute the camera move in compositing.

The Embassy animated the Mark 1 in Softimage’s XSI — which features user-friendly tools for manipulating motion capture data — then imported it into NewTek’s Lightwave for final rendering. “He was rendered into the environment with an HDRI shot on set,” noted Helgason. “We set up a nodal point camera and shot multiple exposures with a fisheye lens that would do a complete 360 around the set. It did roughly 180, 180, 180 — so, of course, we wound up with more than 360; but once we stitched it together we had a very high-rez, high-quality HDRI.” To project reflections of fire back onto the CG character, The Embassy either shot separate flame elements or used fire that was in the live-action plates. “We’d just place polygons around *Iron Man* and project fire onto them so that he would reflect firelight.”

A shot of *Iron Man* firing his flamethrowers for the first time featured a hybrid practical/CG character, with Mark 1 CG legs tracked to a stunt performer in the upper half of the suit. “The actor in the suit had to walk down a hill,” explained Helgason, “and he just couldn’t do it in the suit. So he wore the upper part of the suit, and I taped tracking markers to his underwear for the lower part. Then we just hand-tracked *Iron Man*’s CG legs onto the practical torso, matching the lighting, top and bottom.”

The special effects crew had executed a number of pyrotechnic gags on set, but The Embassy augmented the mayhem. Compositors David Casey and Wendy Whaley, overseen by compositing supervisor Stephen Pepper, added CG smoke and practical fire elements shot against black by production. The Embassy also enhanced and cleaned up practical flamethrower effects. “We had to do a lot of rig removals because there were hoses coming off his back to power these flamethrowers,” said Helgason. “Also, there was an issue with the practical flamethrowers in that liquid shot out of them for the first few feet, and then would ignite — and production didn’t want to see the liquid. So we painted back over the liquid in compositing.”



Computer-assisted and powered by Stark’s ‘repulsor technology,’ the Mark 2’s refinements include flight capability and built-in weaponry, such as destructive beams of energy that shoot out from the suit gloves. The Orphanage developed the internally animated, vaporized-air look of the RT thrusters in early tests, and then ILM expounded on that work for its final shots. For a scene in which Stark tests the RT gloves in his workshop, The Orphanage tracked 3D elements to Robert Downey’s hand, and then subjected those CG elements to additional processing in compositing.

Digital flamethrower effects involved complex simulations that stretched the limits of The Embassy's in-house research and development resources. Attempts to develop a look through Next Limit's RealFlow liquid dynamics were promising; but the required flame effects involved millions of particles that were difficult to control. "If we had to shoot a flamethrower straight out," said Helgason, "it looked okay; but as soon as it started interacting with things, it was much too calculation intensive. So we went to Scanline, the German company, and their Flowline simulation." Scanline supervisor Stephan Trojansky supervised the project, taking delivery from The Embassy of shots that had been tracked and imported into Maya to work with the company's pipeline. Scanline rendered its flamethrower simulations and sent those renders back to The Embassy for final compositing.

Wandering the Afghanistan desert — his suit of armor smashed to bits in a crash landing — Stark is rescued by military helicopters. Upon his return home, he addresses the press at Stark Industries, announcing that his company will cease production of military weapons. Aerial plates shot over downtown Long Beach provided the setting for Stark Industries, while the office building itself was filmed ten miles to the south, then nestled into the Long Beach plates by ILM's digimatte team.

Back in his high-tech workshop, Stark begins building the Mark 2 suit, his aim to use technology and his engineering genius for good rather than evil. At ILM, Bruce Holcomb took the lead in building the CG Mark 2 model, extrapolating from original concept designs and the practical Winston Studio suit. "In CG," Ben Snow commented, "we wanted to extend the performance of the *Iron Man* suit so that it would include complex pieces folding out as it changed from one mode to another. Jon Favreau also wanted it to have even more heroic proportions — proportions that you couldn't achieve with something a real person had to wear. So when Bruce started building our CG suit, he first did a round of rapid prototyping. He sat next to Jon Favreau and John Nelson, pushing and pulling the suit model around until he'd achieved what they wanted, aesthetically. In the end, the CG suit was about three inches taller than the practical suit. It was close enough so that the difference wasn't noticeable, and we still started with data from that suit to build our



In his workshop, Stark tests the Mark 2's RT-powered flight boots. Stunt coordinator Tom Harper suspended Downey from a specialized flying rig that simulated lift emanating from the actor's feet, and then flew him around the workshop set — built by production designer J. Michael Riva — in a series of complex moves. In postproduction, the ILM team erased the gantry rig and wires from the plates, and then tracked in 3D RT thruster elements. ILM also tracked in interactive lighting elements, captured by filming a stuntman in the flying rig wearing boots to which lights were affixed.



model — but the more heroic proportions added a ‘wow’ factor to the CG suit.”

The standard method of using laser scanning to acquire the base CG geometry was not a practical solution for the digital Mark 2, as lasers would have bounced off the suit’s highly reflective surface.

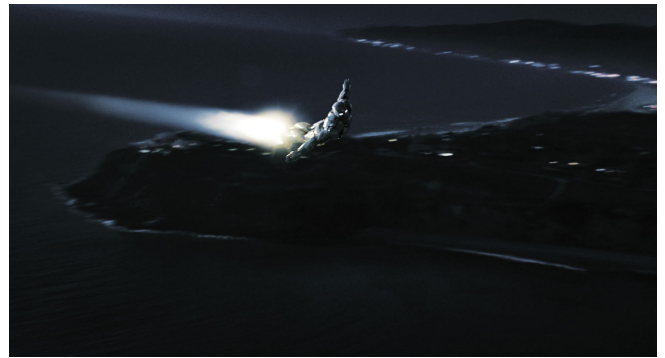
Instead, ILM used a photogrammetry approach that involved multiple cameras capturing many photographs of the practical suit from every conceivable angle. Though the technique ultimately worked, the brushed-chrome surface of the suit proved an obstacle to capturing sufficiently detailed photographs. “It was extremely difficult,” recalled Snow, “but we finally nailed it. We used that data in combination with Winston Studio’s CAD data as the basis for our Mark 2 model.”

The shiny metallic surface of the Mark 2 suit presented challenges at every stage of creating the CG character. ILM had dealt with shiny metallic objects in CG before — everything from the T-1000 in *Terminator 2* to the spaceships and droids in *Star Wars* to robots and vehicles in *Transformers* — but the chrome Mark 2 would be seen in extreme closeups, often cut back to back with the real suit, which required an exceptionally high level of photorealism. “Going into this,” Snow said, “we thought, ‘Oh, come on, it’s just a shiny metal suit — we can do shiny metal in CG!’ But when you have to take it that little bit further and make it look that much more real, it just gets that much harder.”

The ILM crew took many digital photographs of the real suit on the set, intending to make use of standard HDRI to model lighting and reflections. But, realizing that HDRI alone would not suffice, the team also explored technology related to ‘bidirectional reflectance distribution function,’ a term that describes the changing appearance of objects when illuminated from different angles. “We did some work related to this BRDF,” stated Snow. “You take a single point on the surface of a material — in this case, the Iron Man suit — and you have that material oriented to a camera. You also have a single light source, and you move that light source to every conceivable position. So the camera stays fixed, the material stays fixed, but the light moves around. What you get out of that is a giant table of numbers that shows how much light would be reflected from any given point on the surface, regardless of what angle the light is at. And that information would allow us to create lighting models.”

Stan Winston Studio provided ILM with inch-square pieces of the Mark 2 and Mark 3 materials, which ILM subsequently sent to a laboratory in Russia — one of the few facilities in the world

In his workshop, Stark tests the Mark 2’s RT-powered flight boots. Stunt coordinator Tom Harper suspended Downey from a specialized flying rig that simulated lift emanating from the actor’s feet, and then flew him around the workshop set — built by production designer J. Michael Riva — in a series of complex moves. In postproduction, the ILM team erased the gantry rig and wires from the plates, and then tracked in 3D RT thruster elements. ILM also tracked in interactive lighting elements, captured by filming a stuntman in the flying rig wearing boots to which lights were affixed.



In the exuberant ‘first flight’ sequence, Stark — wearing the Mark 2 Iron Man suit — soars out of his cliff-top home and climbs skyward. To realize the sequence, ILM integrated its CG Iron Man with a Point Dume helicopter plate — shot day-for-night due to the darkness of the state beach area. A Jon Favreau mandate that no lighting cheats be employed in the sequence required ILM to illuminate the silver character in the night sky using only the moon, faint city lights below, and the glow from the RT thrusters as light sources.

equipped to gather precise BRDF data. Though the company was able to extract BRDF data from the red-and-gold Mark 3 material, it had no success with the silver Mark 2. “They had the silver material on their machine for two weeks,” said Snow, “and it ended up breaking it! They finally gave up, and said, ‘We just can’t do this on this silver material.’ But we got enough information from this process that CG supervisor Doug Smythe and lead TD Pat Myers were able to go in and do it by brute force, old school. They worked with our R&D folks to change the way we reflected light off brushed surfaces. There was no other way to go.”

In addition to overseeing the Mark 2 exoskeleton model, Bruce Holcomb worked with James Tooley’s creature team to build an endoskeleton of gears and levers, suggesting the underlying mechanics of the suit. The endoskeleton, designed to actually fit inside the suit’s outer armor, provided for shots of suit flaps opening or rotating, revealing the mechanical gadgetry. “All of these mechanical gadgets had to make sense, too,” said Snow, “because Jon Favreau didn’t want an *Iron Man* suit that could do magical transformations. Everything we built had to be conceptually possible within that suit design. We always had to think about how a particular piece would fold out, where it would fit — and I think the modelers really liked that constraint. Of course, realistically, once all of that stuff was in the suit, there would have been only about an inch in diameter for a person to fit into!”

The all-CG *Iron Man* was featured in flying and other dynamic action sequences; but for more intimate, performance-driven scenes in which Robert Downey Jr. was only partially suited up, ILM tracked individual sections of the CG suit to the actor, freeing him from the heavy practical suit pieces and allowing him more flexibility in performance.

Tracking was facilitated by the use of iMocap, ILM’s on-set motion capture technology. “iMocap allowed us to actually put the actor in the environment without him having to wear the whole crazy suit,” explained Jon Favreau. “It allowed us to film Robert as if we were making a regular movie — and then ILM built the whole suit around him. You always get better performances and camera work when you have a real person in there, rather than an empty plate that a CG character will go into. You frame to it better and it has that analog feeling that we were going for.”

The mix of practical suit pieces and tracked CG pieces varied from shot to shot and was determined by the actor’s comfort level and by the nature of the action in a scene. In some cases, Downey would wear a full iMocap suit and just the practical helmet, with ILM tracking the entire body of the CG suit in postproduction. In another shot, he might wear only the real chest plate, and ILM would have to track in the rest of the suit body, as well as the helmet.



The first flight sequence introduces the ‘heads-up displays’ featured throughout the film as a means to maintain the connection between the characters of Tony Stark and Iron Man. Designed and executed by The Orphanage, the HUDs reveal the data-rich environment within the Iron Man mask as Stark interfaces with ‘Jarvis,’ the computer that controls the suit’s functions. For shots of Stark inside the mask, The Orphanage overlaid 3D and 2D graphics on greenscreen closeups of Robert Downey Jr. The Orphanage integrated graphics with production plates for shots of Stark’s point of view – such as his aerial view of Los Angeles and environs during the first flight.

In addition to facilitating tracking of CG suit pieces to the actor, the iMocap recording of Downey's performance provided reference for animation of the all-CG *Iron Man* by animation supervisor Hal Hickel and his team. "Jon Favreau wanted *Iron Man* to have a very heroic style of movement and action," observed Ben Snow, "and yet, *Iron Man* had to be Robert Downey Jr., as well. There was this duality in the character that we had to achieve in the animation — especially in shots where there was a transition from the actor to the digital character, or vice versa. We often had to blend from the superhero *Iron Man* striding into place to the Tony Stark character; and the animators had to nail some of that Stark character in order for the blend to work. So they would do little animation tweaks to integrate some of the actor's head and body movements into *Iron Man*. That didn't apply to the more heroic, action-oriented shots, though. In the big action stuff, there was a much bigger difference between the power-assisted *Iron Man* and the 'Robert' *Iron Man*."

Facial animation was not a factor in the character's performance, as the *Iron Man* helmet was designed as a rigid piece without moving parts in the mask. As far back as the testing phase, Favreau and John Nelson had informed ILM that there should never be animation of the mask within a shot — although slight changes of the mask shape from one shot to another had been considered as a means of creating subtle shifts in expression. Even that animation cheat was abandoned, however, as animators discovered they could create attitude just in the way the head tilted or turned. Emotional states were also suggested through alterations in lighting. Casting the 'brow' area of the mask in shadow, for example, resulted in a slightly angry look.

With the Mark 2, Stark refines the repulsor technology that enables him to fly. In a series of workshop scenes, Stark tests his flight capabilities wearing only flight boots and arm control devices. To capture live-action of Downey airborne within the workshop set, stunt coordinator Tom Harper suspended the actor from a special Zero Gravity gantry — rigged so that it would appear that lift was emanating from the actor's feet rather than from a traditional torso harness. Production also shot a stunt performer in the flying rig, with lights strapped to the boots to create interactive illumination and lens flares.

Presented with the plates, ILM's roto team, led by Amy Shepard, had to first digitally erase the gantry rig — a labor-intensive task in itself, due to the scenes' complex camera moves — and then track in computer generated repulsor technology thrusters. ILM tracked 3D elements to Robert Downey Jr.'s feet and arms, and then processed those elements in compositing. ILM also retrofitted the Winston Studio gauntlets the actor wore on his arms when Favreau decided the practical pieces were too large. On the set, the Winston team quickly repurposed another, smaller piece for Downey to wear; but with only one such piece available, ILM had to track in a digital gauntlet on the actor's



Stark dons a state-of-the-art Mark 3 suit for a rescue mission in a Middle East village where well-armed insurgents are terrorizing innocents. Having killed the insurgents and destroyed their weapons cache, Iron Man flies home, intercepted en route by U.S. Air Force F-22 fighter jets. To ensure realism in the sequence, production shot air-to-air plates of real training jets executing dogfight maneuvers in the skies over Lone Pine, California. In postproduction, ILM digitally removed the actual aircraft and tracked in computer generated F-22s and its 3D Iron Man, massaging in all of the lighting glints and lens flares evident in the original aerial footage.

naked arm for every shot. “It’s one of those effects that was a lot of work,” said Ben Snow, “and, hopefully, no one will ever notice it!”

In a later scene, Stark tests all of the mechanical flying surfaces of the completed Mark 2 as the camera dollies around it. Initially, ILM replaced only a few areas of the practical suit with its articulated CG mechanisms; but Jon Favreau and the Marvel team were so pleased with the effect, they asked for more mechanical gags. “A lot of that work evolved from the endoskeleton stuff Bruce Holcomb had built into the original *Iron Man* model,” said Snow. “With Keiji Yamaguchi and Tom Brakensiek of the creature team, we threw around ideas of what the suit could be doing: ‘Okay, he’s got flaps that help him steer while he’s flying, so we’ll have those fold out here.’ Keiji and Tom would rough those things in, and then Bruce would flesh it out with underlying mechanisms. When he came to look at final shots, Jon Favreau forgot what parts of the suit were CG and what parts were real — and that’s when we knew we’d nailed the photorealism he was after.”

The following ‘first flight’ sequence, set at night, has *Iron Man* soaring out of his house and over the Los Angeles basin. The shots were comprised of aerial plates of Point Dume and Los Angeles that John Nelson had filmed from a helicopter — the former shot day-for-night due to the darkness of the state beach area — and ILM’s CG Mark 2. The most difficult part of the sequence was illuminating the silver character in the night sky, a job that fell to Doug Smythe and his team. The assignment was especially challenging given Jon Favreau’s mandate that no lighting cheats be used. All of the illumination on the suit had to come from logical sources — the moon, the faint lights of the city below, the glow from the eye area of *Iron Man*’s mask, and the RT thrusters.

Iron Man’s flight animation, too, was grounded in real-world physics, rather than in virtual-world fantasies. “We actually motion captured people in a wind tunnel with Giant Studios,” noted John Nelson, “and then turned that data over to ILM. Ultimately it



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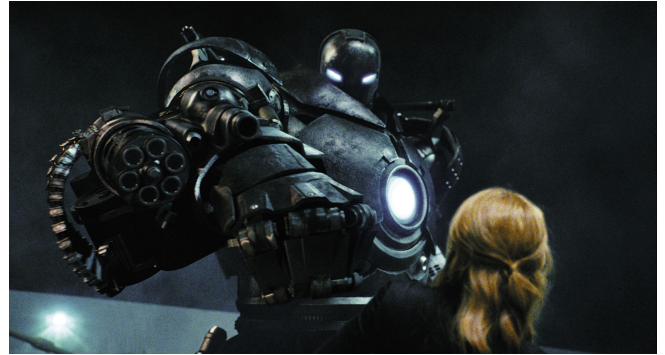


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was used only as reference, as the body motion wasn't rigid enough; but it got us thinking about force vectors and air dynamics. One thing we determined was that *Iron Man* would never float — he would either be powered by his RT thrusters or drop like a stone — and the point of thrust always had to be from his RT boots to look correct.” Aircraft footage provided the most useful reference for the animators, since *Iron Man*'s armored suit in flight resembled nothing so much as a high-powered jet, complete with thrusters and flight surfaces that constantly corrected and adjusted to keep him airborne.

to the actor and added computer animated mechanical appendages to the shot.

The first flight sequence introduces the heads-up displays seen throughout the rest of the film — closeup views of Robert Downey Jr. within the *Iron Man* helmet, or his POV from inside, as he interacts with Jarvis, the computer controlling the suit. “Cutting to Robert inside the suit was a way of connecting the character of Tony Stark with *Iron Man*,” observed Jon Favreau. “Masked superhero movies always have the challenge of the audience connecting the character with the superhero. *Spider-Man* has that problem, which is why he pops off that mask all the time. But we couldn't do that with *Iron Man*. So, instead, we came up with a really cool, layered interface that suggests a virtual environment inside the helmet, and we cut to that from time to time. You see layers of graphics popping up, overlaid onto what he is seeing from inside the helmet; or you are looking back at him through those layers.”



In the film's climactic sequence, Pepper Potts is menaced by Iron Monger — Obadiah Stane (Jeff Bridges) in a powerful suit he has built from stolen arc reactor technology. ILM based its CG Iron Monger on a full-size puppet built by Stan Winston Studio. John Nelson and the ILM and Winston crews collaborated to capture as many shots as possible in-camera, with Bridges performing in the upper-half of the practical Iron Monger suit.

For the heads-up displays, production shot greenscreen closeups of Robert Downey Jr. on 70mm to provide The Orphanage with live-action elements they could push into, if necessary. “They followed a script to give Downey an idea of where the data he was calling for would be in the space in front of him,” said The Orphanage visual effects supervisor Jonathan Rothbart. “There were lights out in front of Robert to guide him as to where he should be looking, so his eyes would properly cue the motion graphics applied later.” The Orphanage designed the graphics — with PLF's Kent Seki providing guidance from the production side — extrapolating from data displays in fighter jets and high-end vehicles. “For all of the heads-up displays, we wanted to make the graphics as simple and readable as possible, because there was a lot of information coming all at once. In addition to the graphics, we also created some 3D models — turntables and things like that — and then we put everything together in Nuke.”

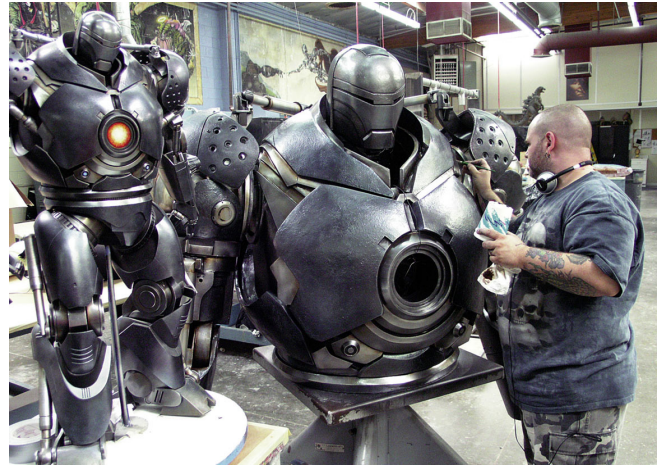
“I wanted to push beyond a simple X and Y space,” added John Nelson, “and use Z space with stuff flying into his field of vision — so different pieces of information were constantly flying in from just off screen, alluding to a greater whole. When Tony moved his eyes, graphics would come in to meet his gaze, creating a dialogue between Tony and the interface.”

The heads-up displays broke down into two primary modes: data-seeking mode in which *Iron Man* gathered information on his surroundings or ran diagnostics on the suit itself; and flight mode, which included an artificial horizon and other types of data that would be seen in the cockpit of a jet. For a shot in which *Iron Man* calls up the flight pattern from LAX, The Orphanage researched how such flight patterns are presented to the airport's real tower operators. "Tony is hacking into the airport ground control system to read the flight patterns," Jonathan Rothbart said, "so we exactly matched air traffic control data to maintain as much of a sense of reality as possible."

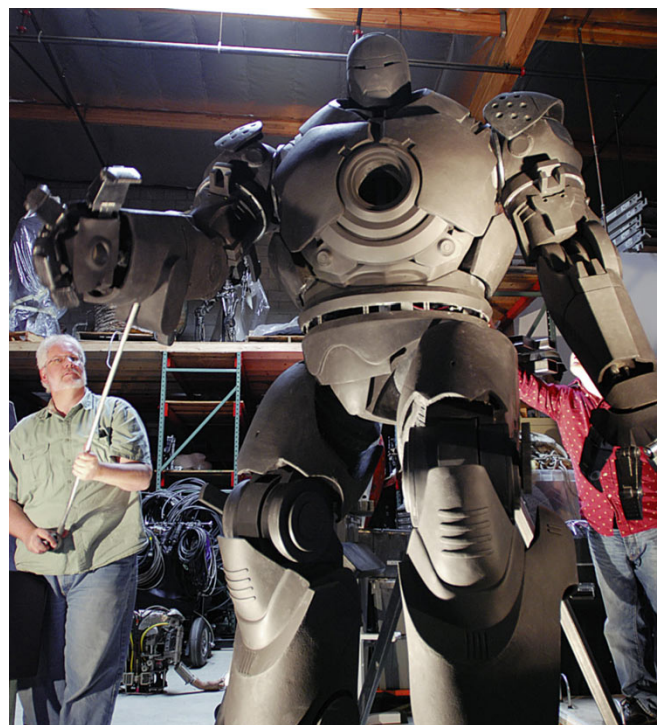
For shots of Stark's POV from inside the suit, The Orphanage layered graphics over production plates that were left untreated or digitized, except for a slight color shift toward cyan. "Even though the look was designed as a computer-assisted view that Tony Stark was seeing," said Rothbart, "we didn't want to get into anything that looked like you were seeing an environment through a screen. We wanted it to still feel like a normal first-person view."

Testing the limits of the suit, Stark flies beyond the atmosphere, into outer space — a synthetic environment created by ILM. The cold temperatures at the higher altitude cause the suit to freeze and its mechanisms to shut down. ILM added a layer of digital ice to the CG figure, rendering it through ray-tracing to create a refraction effect. Particle systems created sprays of ice as *Iron Man* — in freefall — uses an emergency system to re-ignite the suit and break free of the ice casing. "At that point," said Ben Snow, "the ice flies off of him, and flaps and other mechanical parts start to move and open."

Iron Man's last-second recovery has him soaring low over traffic on Wilshire Boulevard. "I'm very proud of that little sequence," noted John Nelson. "We were trying to figure out how to create a sense of jeopardy as Tony narrowly misses the ground; and so one night after we'd wrapped, I took my little digital still camera — which has a movie mode on it — and drove around Westwood, shooting the camera out the car window. Then I gave that to the previz team, and said: 'Here's an idea for when Tony comes down. I think we can make him recover so narrowly that he actually flies right down Wilshire Boulevard.' We put *Iron Man* in that footage and showed it to Jon, and he thought it was cool. But the origination of it was just



Winston Studio crew member John Cherevka paints the full-scale Iron Monger, using the third-scale maquette as reference. Initially assigned to build a rigid Iron Monger suit that would be used only as a lighting stand-in, Shane Mahan and his team built the character with moveable joints and swiveling hips so that it might be employed as an articulated puppet on set.



me driving around Westwood with my hand out the window! We shot the actual plates for that from a van, driving down Wilshire at dusk.”

Though Jeff Bridges or a double could actuate some Monger functions within the suit, practical arms were rod-controlled by Winston puppeteers off-camera. Dave Merritt and Shane Mahan rehearse puppet arm controls at the Winston shop.

Stark presumably solves the icing problem with the state-of-the-art Mark 3 suit — a hot-rod vision in red and gold. A scene in which Stark suits up in the Mark 3 via sophisticated mechanical arms had been in the original script, but had been cut so that production could meet its budget. Later, Marvel freed up the resources to reinsert the suit-up sequence. “It was the kind of scene we knew the audience would want to see,” observed Jon Favreau. “Without it, it would have been like Clark Kent going into a phone booth and coming out as *Superman*. Tony Stark would just come out as *Iron Man*, without the audience seeing how he got into the suit. Like the heads-up displays, watching Stark get suited up was a way to connect the character to *Iron Man*. Fortunately, the fact that we came in on time and on budget made Marvel comfortable with the idea of kicking in a bit more money for the suit-up.”

As an after-the-fact sequence, the suit-up had to be assembled from material not originally intended for that purpose. “When the studio decided it wanted this suit-up sequence,” said John Nelson, “I went back to a 360-degree Steadicam shot moving around the Mark 2 suit, and cherry-picked all the backgrounds from that. We prevized the whole suit-up sequence over those backgrounds, and then we shot a stunt guy over at New Deal Studios’ stage, just walking in with bluescreen on the floor, matching action to our previz.”

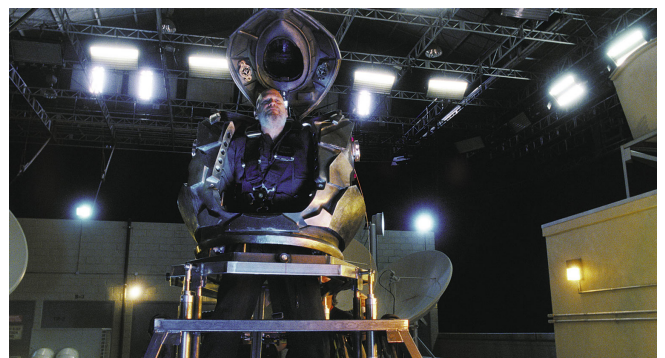
“By that time,” added Victoria Alonso, “Robert Downey was already on another movie, and so we couldn’t get him in time to shoot this sequence. The idea of the suit-up wasn’t about Robert, anyway — it was about the suit, and the mechanics of getting into the suit. So the creative team chose angles that didn’t show too much of Tony Stark.”

ILM fabricated the entire scene, first augmenting the Steadicam backgrounds with virtual tiles created from high-resolution photographs of the workshop set. From designs by ILM art director Aaron McBride, modeler Russell Paul built CG robotic arm models and other mechanical gadgets that interacted with CG suit pieces. ILM also executed face replacements on the bluescreen stunt performer when Jon Favreau determined that he was not a convincing enough double for Robert Downey Jr. — even shot from behind and from oblique angles. “Luckily,” said Alonso, “ILM had taken a lot of digital photos of Robert, and they were able to utilize those photographs on the head of our stunt double. And then, at the very end of production, we were able to get Robert for the last full-front shot in the suit-up sequence.”

Iron Man performs his first act of heroism in the Mark 3 suit, arriving in the Afghan village of Gulmira — near the site of his captivity — to rescue villagers from insurgents in possession of Stark Industries weapons. In a sequence of shots designed around the test produced by The Orphanage, *Iron Man* fires beams of destructive RT energy from his gloves, taking out the villains and their weapons cache. “The Orphanage was the first to crack what the RT would look like,” said John Nelson. “It isn’t just a flare — it has internal animation, and it leaves a trail of smoke, as if it is so hot it actually vaporizes air.” Production shot a stuntman wearing an iMocap suit for the scene, and then ILM tracked in the CG suit, as well as the RT particle beam effects.

Featured in the *Iron Man* trailers were shots from the Gulmira sequence in which *Iron Man* fires a small arm missile at an enemy tank in the background, then turns and walks toward camera. Though Dan Sudick's crew had orchestrated on-set pyrotechnics for the aftermath of the action, the tank explosion itself was achieved digitally at The Orphanage. "The tank was CG," related Jonathan Rothbart, "and we integrated the CG explosion on it with the live-action stuff. Only a small portion of that sequence was plate. We did a lot of set extension and environment work, adding smoke and fires and skies to fill that out." The Orphanage also modeled and animated a CG *Iron Man* for the trailer; but the final shot as it appeared in the film featured ILM's *Iron Man* composited into The Orphanage's background.

During his flight home from Gulmira, *Iron Man* is detected by the U.S. Air Force, which dispatches F-22 fighter jets to bring down what it assumes to be an enemy aircraft. The subsequent dogfight lent itself to an all-synthetic approach; but, again in service to realism, Jon Favreau elected to shoot real aerial plates, deriving inspiration from 1986's *Top Gun*. "*Top Gun* was the height of practical filmmaking with jet planes," said Favreau. "Much like the way George Lucas pulled up old *World War II* dogfight footage and based some of his *Star Wars* shots on that, we took apart shots from films like *Top Gun* and forced ourselves to use the same practical methods they'd used to get our plates for the dogfight. Rather than putting virtual cameras anywhere, we always had our camera shooting from a platform. If we were in a tight shot, we made sure the lens would be long enough that it would seem as if it was shot from another plane. When we went up to shoot plates, we didn't just have a cameraman doing a pan through the sky, we actually sent up airplanes to do maneuvers. We had a whole aerial unit so we could get all the idiosyncrasies of the camera work, the lenses and lens flares, the scratches and condensation — all the things you saw in *Top Gun* and didn't see in *Stealth*, which was a similar type of story, but told through the tools of CG. *Stealth* moved the camera around in a very dynamic way; but you felt connected to the action in *Top Gun*, viscerally, in a way you didn't feel in *Stealth*. I felt that my responsibility was to make this dogfight action as photoreal as possible, not necessarily as dynamic as possible."



Jeff Bridges performs inside the partial Iron Monger suit, attached to a pneumatically supported, wheeled gimbal rig to facilitate on-set mobility. Dan Sudick's special effects team welded the rig together, based on a Winston Studio design, just prior to the start of filming. The rig was either framed out of the shot or painted out digitally in postproduction. To avoid rod puppeteering on set, the Monger suit was often shot without the arms attached.

With cameras mounted to a Lear jet, a helicopter and a mountaintop, production shot two 1960s-era military training aircraft as they performed a variety of aerial maneuvers in the skies over Lone Pine. “Since the planes were going to be replaced with CG aircraft and *Iron Man* in final shots, it was essentially a surrogate shoot for us,” said John Nelson. “But it was very helpful in creating that sequence, because the real movement of the camera and the aerial maneuvers of the vintage jets provided realistic dynamics for *Iron Man* and the F-22s that would be added later in CG. In addition to giving us something to frame to and shoot, the real planes also became lighting references for the CG F-22s and for *Iron Man*.” Wes Sewell, Ben Snow and Kevin LaRosa shot the aerial plates, roughly matching the dogfight sequence previz.

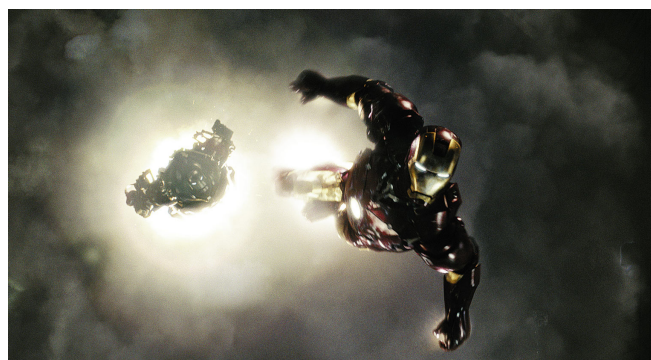
In some cases, the ILM team — working under CG supervisor Philippe Rebour and compositing supervisor Jeff Sutherland — tracked its CG planes and character over the aircraft in the plates, exactly mirroring the planes’ maneuvers and painting out areas not occluded by the sleeker F-22s and *Iron Man*. More often, ILM completely removed the real aircraft in the plates so as not to be limited to that aerial action. “Once we started animating this stuff,” Ben Snow remarked, “we found that we could get even more dynamic behaviors in the F-22s — still using the real camera moves in the plates. But it was still good to have that foundation of real photography to build all of this on.”

Iron Man escapes the F-22s, but soon finds himself in battle with another metal-clad nemesis — Iron Monger, the alter ego of Stark Industries executive Obadiah Stane (Jeff Bridges), who has built a larger and more deadly suit with stolen arc reactor technology. Bridges was able to initiate upper-body Iron Monger moves from inside the Winston Studio suit, while crew members pushing the large wheeled gimbal rig on which the puppet was mounted created gross movement of the character through the set. Puppeteers off-camera moved the arms via rods.

Both the ILM and Winston Studio crews were committed to capturing as many in-camera shots with the rig as possible. “My position was that if we could get the shot practically, that just left us more resources to spend on the bigger shots,” said Ben Snow. “If it was a shot that didn’t have to be



ILM tracked in CG Iron Monger arms and legs in postproduction. In many shots, ILM isolated Jeff Bridges in the practical suit, and then surrounded him with an all-CG Monger. To make it appear as if the character was walking across set — rather than being wheeled — ILM’s layout team re-animated Bridges’ actions slightly, using the company’s Zeno animation rig to give animators total control over his motion.



Unable to beat the larger and more powerful Iron Monger on terra firma, Iron Man leads him in a high-altitude flight, hoping the colder temperatures will freeze and disable the villain’s suit. ILM realized the all-CG sequence, integrating its animated Iron Man and Iron Monger characters within a synthetic atmospheric environment. Subsequent shots of Monger’s suit freezing featured digital ice, rendered through ray-tracing to create refraction effects.

CG, I didn't want to do it CG. And of course, the Winston guys wanted their suits used as much as possible, as well."

In postproduction, ILM either replaced just the lower part of the rig with CG Iron Monger legs or — more often — isolated and replaced the upper body, as well. "We wanted to stay true to Jeff Bridges' performance in the Iron Monger suit," said Snow, "but when we wanted him to move up and down, as if he was really walking rather than being wheeled across set, Colin Benoit's layout team would put him on our Zeno animation rig to give the animators complete control over his motion. Then, in compositing, we would track Jeff Bridges to what the creature was doing, rather than be stuck with the wheeling of the rig across the stage." John Walker was the look development lead on the CG Monger, while Ron Woodall developed paint schemes representing the character at various stages of wear and tear.



Iron Man bests Iron Monger in a final mano-a-mano battle on the rooftop of the Stark Industries building. Rather than an elegant, kung fu style fight often seen in superhero movies, Jon Favreau instructed ILM animators to create a violent, chaotic, bare-knuckle brawl between the two characters. Production shot live-action for the fight sequence on a rooftop set, which ILM augmented in some shots with a digital cyclorama of the city in the background.

The end battle starts with Iron Monger chasing and firing at Stark's assistant Pepper Potts (Gwyneth Paltrow) within the Stark Industries building. To capture the chase, production planned on shooting plates of Paltrow running down a corridor set as pyrotechnics rigged by the special effects team exploded around her. ILM would then introduce its CG Iron Monger into those plates.

To establish timings, production first shot a rehearsal take of Paltrow running through the set — without pyro — as an assistant director wearing a cardboard cutout of Iron Monger on a backpack rig ran behind her. "We shot that rehearsal pass on film just so we could get the timings down and make sure the camera was right," explained Snow. "Then we went back in with Gwyneth and shot the take for real, with all the pyro events going off. But there were a lot of technical limitations on her during that take, for reasons of photography and safety. And when we started working on the shot, we realized that mostly because of those technical limitations, she didn't look as scared as she had in the rehearsal take. So we decided to use the rehearsal footage of Gwyneth — where she was looking very scared and running flat out, without worrying about hitting her marks — as the actual plate, and then add in all the pyro from the other plate. It required a lot of hand work; but with the tools we have now to reposition people and track plates together, it worked out well."

Pepper temporarily escapes Monger, but is menaced by him again when he erupts from the ground near her — a shot comprised of the CG Iron Monger and a heavy dynamics simulation to create the cracking and crumbling ground. *Iron Man* arrives on the scene, crashing with Iron Monger through the walls of the building and out onto a freeway, where they become embroiled in traffic. Plates for the freeway sequence were shot by the second unit, at night, on a closed section of freeway in Long Beach. ILM added in the CG characters, and also created much of the destruction of vehicles using particle and rigid body simulations. "Dan Sudick's crew had done a lot of really cool practical car effects," said Snow, "but we added CG cars to create more traffic and destruction."

At one point in the action, Iron Monger lifts an SUV carrying a mother and her children over his head. Sudick's crew had mounted the vehicle — with stunt performers inside — on a practical crane rig, puppeteered via a waldo mechanism to look as if it was being lifted and swung overhead by Iron Monger. "We were able to use that for one or two shots," Snow commented, "but of course, once we had the real Monger animation going, the director didn't want to be constrained by what was shot with this rig suspended from a crane. So we wound up re-creating the car in CG, and putting the family from the practical shots inside the CG car."

To finish off *Iron Man*, Monger throws him into a bus and fires a rocket, causing the bus to explode in a massive ball of fire. Sudick's crew executed the bus explosion as a practical effect on the freeway in Long Beach, and production covered the event from multiple cameras. Thinking a wide digimatte shot of the explosion might be required, the ILM crew also covered the event from three HD cameras positioned on the roof of a nearby skyscraper. One of those HD views served as the basis for a key shot added later in postproduction. "They wanted the *Die Hard 2* shot of *Iron Man* being catapulted out of the exploding bus and coming right up to camera," explained Snow, "but none of the plates they'd shot had that high camera angle. Our HD camera angle was the closest. It wasn't perfectly placed for this shot, either, but it was placed well enough. So we cleaned up that HD footage and enhanced it with additional explosions and digital matte elements to create this shot."

From the freeway, Stark leads Iron Monger in a flight into outer space. In the higher altitude, Monger's suit mechanisms freeze — just as *Iron Man*'s did in the first flight sequence — and the character goes into freefall. "That was a big digital sequence," stated John Nelson. "The only plate contribution to that was diving from 18,000 feet to 11,000 feet — pretty much straight down — in a Lear jet that had a nose-cam on it. We cleared it with the flight controller by describing it as a 'gradual descent,' but there was nothing gradual about it! Everything inside the jet flew up and went to zero G." ILM sequence lead Leandro Estebecorena created the outer space environment using a starfield generator the company had been developing and building upon for many years, and then blended that with the aerial footage of the distant cityscape below.

With his suit power running dangerously low, *Iron Man* returns to the roof of Stark Industries, the site of a final battle with Iron Monger. Production shot live-action for the scene on a full-size set; but between principal photography and the end of postproduction, the rooftop action had been rethought to such an extent that ILM had to digitally alter the live-action. "We shot it with a particular aim in mind, and then we had to adapt it," remarked Snow. "One of the new ideas was that *Iron Man* would relax on the rooftop and take off part of his suit. Earlier, he'd taken off one of his gloves, but for a very different reason; and so we had a Robert Downey Jr. performance that didn't go through all the motions of his starting to take off his costume. We'd shot Robert wearing only the mask of the suit, so we were always planning to track our CG *Iron Man* to his motions; but we had to alter Robert's performance itself so that it would look as if he was starting to take off the suit. He starts to unbuckle his helmet; and when the helmet opens, it's really Robert. The armor was tracked to his performance from then on."

Iron Monger fires a missile at *Iron Man* on the rooftop. Live elements included an over-*Iron-Man*'s-shoulder view of Jeff Bridges in the open Iron Monger suit, aiming the missile — a practical rocket that the special effects team had fired across the set — and a pyrotechnic gag that exploded at the

other end. The intention had been to track CG Iron Monger arms to the practical suit to get dynamic limb movement as the character fires the missile. But when the shot was framed up on stage, Ben Snow realized that the shot might be able to be achieved entirely in camera. “I thought if we could just get the practical arms on the Monger rig and have guys puppeteer them, we could get away with the shot not being digital at all,” said Snow. “So I suggested this to the Winston guys, and they were all over it. They hustled and got the practical arms on the Monger suit and got the puppeteers ready — and we shot it like that. In the end, we did some digital work on the background, creating a distant cyclorama of the city, and a little bit of rod removal; but all the performance of Jeff Bridges as Monger was puppeteered on the set. Shane Mahan came up to me later, and said, ‘Man, if you have any more ideas like that, please speak up!’”

In a sequence featuring the all-CG *Iron Man* and Iron Monger, the rivals engage in hand-to-hand combat on the Stark Industries roof. In the course of the fight, Stark lands on the skylight over the massive arc reactor below — a full-size set built at Downey Studios, enhanced with particle effects inside a Ron Woodall model, all composited by Saber artist Dean Yerka. As Iron Monger advances on him, *Iron Man* instructs Pepper Potts to overload the reactor, which will set off an electromagnetic pulse and knock out the power on Iron Monger’s suit. The discharge of energy reaches into the sky in a giant column, creating a lightning storm within dark clouds.

To create the lightning look, ILM built upon recently developed hair modeling tools that enable artists to control hairs procedurally as well as by hand sculpting. “Our R&D folks leveraged those tools to allow us to create infinite amounts of this lightning material,” related Snow. “That was combined with some digital matte paintings of the Stark campus, and some old-school backlit cloud stuff that Paul Huston shot on our stage. He set up backlit cotton wool and shot it in different passes. David Hisanga combined that with a large volumetric cloud simulation, so that we could have the clouds open.” With the explosion of energy, Iron Monger falls — presumably to his death — into the arc reactor shaft, a miniature built by New Deal Studios. A down-angle of Monger hitting pipes as he descends into the shaft combined ILM CG simulations with pyrotechnic and miniature elements filmed at New Deal by Wes Sewell, Matt Gratzner and Tony Cutrono.

Iron Man survives the explosion, and the film ends with Tony Stark again addressing the press — this time attempting to quell rumors that he is the mysterious man in the iron mask. Always the rebel, Stark finally disregards his carefully prepared notes and declares: “I am *Iron Man*.”

The character established, and with many more nemeses from the comic books for him to battle, the table is set for an *Iron Man* sequel, boxoffice permitting. If there is a sequel, and if Jon Favreau agrees to direct, he will go into the project having benefited from a significant learning curve regarding computer generated effects. Long a vocal detractor of the ways in which CG is used and abused, the director — with *Iron Man* — had learned to avoid the technology’s pitfalls and to appreciate its potential.

That appreciation became clear when, at one point in the postproduction schedule, Favreau made a visit to ILM to speak to the entire effects crew. “He said: ‘Look, I came into this process very critical of CG,’” Ben Snow recalled. “‘But seeing the work you guys are doing, I have to say to the whole crew that you’ve changed my mind.’ It was terrific that he took the time to do that. *Iron Man* was the

show that sort of forced him to use a lot of CG, even though he didn't like it. But, by the end, he had embraced it."

"I never actually hated CG," Favreau clarified. "I'm very much a fan of computer animation, and I think that the stuff Pixar does is sublime. What I don't like is CG being used when you could shoot something practical. *King Kong* was an example of where CG was used correctly; and studying how Peter Jackson used CG in that film made me realize that there was a way to do it right. You need good preparation. You need practical elements mixed in with it. You need enough time. And you need to work with the right effects artists. For *Iron Man*, I not only had Robert Downey, who gave the character a personality, a heart and a soul, I also had visual effects magicians who brought a lot of artistry to it. Working with the vendors I did, and the crew that I did, *Iron Man* was a great experience. I can even say I love CG now."

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Lost World

image

ARTICLE BY JOE FORDHAM

After the popularity of his 1950 fantasy novel *The Lion, the Witch and the Wardrobe*, C.S. Lewis created six more stories that followed the adventures of four English schoolchildren in the enchanted world of Narnia. The second book, *Prince Caspian*, published in 1951, retained the childlike innocence of the first, but took a quantum leap, picking up the story — in Narnia time — some 1,300 years later.

Director Andrew Adamson — who had helmed *The Lion, the Witch and the Wardrobe* for Walden Media and Walt Disney Pictures — used the chronological jump to bring a new sensibility to the second film outing in Narnia. “Narnia is darker,” Adamson commented. “It’s grittier. It’s bigger. There is more action in this story, and more characters. This film had a similar number of visual effects as the first; but, whereas last time we used effects to create a lot of fantasy environments and wintertime in Narnia, this time I shot more practical locations and used effects to increase the range and number of creatures, and to add scope to the battles.”

The screenplay by Adamson, Christopher Markus and Stephen Freely streamlined Lewis’ novel, using a prologue sequence to introduce the young Prince Caspian (Ben Barnes), heir to the Narnia throne, who is deposed by Miraz (Sergio Castellitto), an ambitious Telmarine regent who has laid claim to the kingdom and plans to eradicate Caspian and all of Narnia’s remaining magical creatures. It is to this tumultuous Narnia that the Pevensie children return — guided by a dwarf named Trumpkin (Peter Dinklage) — and eventually lead Caspian into battle against Miraz.

The *Chronicles of Narnia: Prince Caspian* reunited Adamson with producers Mark Johnson and Philip Steuer and many members of the previous Narnia crew. Visual effects supervisor Dean Wright segued into the production after completing the expanded DVD of *The Lion, the Witch and the Wardrobe*. “Andrew needed to take a break after the last film,” recalled Wright. “He left me in charge of a small team, playing supervisor, producer, coordinator and editor. We worked with Soho VFX, using assets that had been created at Rhythm & Hues, to add 80 shots to the first film. I sent Andrew material and he gave me notes. While that was going on, production began on *Caspian*. We didn’t have a script, we just had a short outline, but the delivery date was looming for a May 2008 release. That gave us less than two years to deliver the film.”

Wright and film editor Sim Evan-Jones drew on their familiarity with the previous film to analyze the visual effects requirements for the new film, creating an initial breakdown of 1,600 visual effects shots. “Based on just the outline,” said Wright, “we grouped effects into categories — full CG characters, character enhancements, characters plus environments — and used footage from the last film to illustrate the kinds of shots we wanted vendors to bid on.”

Due to the large number of effects shots and the accelerated schedule, visual effects supervisor Wendy Rogers joined the production to share overall supervisory duties with Wright. “Dean and I split sequences based on what would separate most effectively and our complementary background

experience,” said Rogers. “I had more experience in 3D and animated features, so I took on most of the character development and large 3D character sequences. I didn’t have as much on-set experience as Dean, so it was a real benefit to have him and Andrew as partners. Andrew is a very effects-savvy director. He allows time to shoot clean plates and reference. Our job was to abstract the details that would take Andrew away from his orchestration of the film. We focused on the details, so Andrew could focus on the story and retain his objectivity and original vision.”

The filmmakers established a base of operations in the Czech Republic, and then initiated shooting in New Zealand, followed by locations in Poland, Slovenia and soundstages and backlot work at Barrandov Studios in Prague. The production shift to Europe — based on an equation of scenic resources, local talent pools and financial tax incentives — led to a new start with European visual effects vendors. “We pretty much had to start over,” observed visual effects producer Andy Fowler. “All the vendors from the previous film were asked to hand their assets over to the vendors in London. That was the starting point; but we then had to reinvent all the technology for animation rigs and models and begin again from position one.”

Not all the vendors were new, however. As it had for the first film, Richard Taylor’s Weta Workshop furnished conceptual artwork, weapons, armory and miniatures for the second, and KNB EFX Group returned to design and create all of the practical creature effects. KNB creature effects designers Howard Berger and Greg Nicotero proposed a new design initiative for Prince Caspian. “Narnians in the first film were very virile, in their early 20s or early 30s,” noted Berger. “Greg and I wanted to mix it up with a broader age group, different genders and racial types — child centaurs, child fauns, old satyrs, old centaurs, males and females — to make it feel like a giant civilization. Telmarines had banished all the magical creatures, so we wanted Narnians to have a more primal feel. Their hair was not so coiffed and they were quite wild looking. We tried to heighten that reality in the creature designs, and Andrew gave us carte blanche.”

KNB updated creature looks in maquettes sculpted by an all-star team of artists that included art director Aaron Sims, Eddie Yang, Jordu Schell, Andy Shoenberg and John Wheaton. Howard Berger then oversaw creature work on set with lead makeup effects artist Tami Lane and an international crew of 60 makeup artists and hairdressers. Greg Nicotero refined and supervised the prosthetics build with Alex Diaz, Mike Deak and Shannon Shea, directing a crew of 100 sculptors, moldmakers, foam runners, wig makers and fabricators.

Two breeds of Narnians, prominently featured in the film, received complete makeovers. “I had not been happy with our dwarf characters on the first movie,” Berger confessed. “We had cast little people out of Thailand and India who were small but not really dwarf-like. Fortunately, this time the production cast two fantastic actors for our two lead dwarves — Peter Dinklage as Trumpkin and Warwick Davis as Nikabrik. They set the style for all the dwarf makeups in the film.”



Lucy Pevensie (Georgie Henley) is reunited with Aslan, the lion king of Narnia, in *The Chronicles of Narnia: Prince Caspian*. Andrew Adamson co-wrote and directed the adaptation of C.S. Lewis’ second Narnia novel, depicting

John Wheaton used photographs of Dinklage and Davis to generate a series of Photoshop renderings of the characters, and prosthetic designer Jeremy Aiello sculpted facial prosthetics over lifecasts of the performers. Howard Berger and Tami Lane then applied makeups and custom hairpieces created by KNB hair artist Mark Boley and his team.

the fantasy realm 1,300 years after the events of the previous film. Investing this new Narnia with gritty realism required the combined efforts of KNB EFX Group, which generated practical creatures, Weta Workshop, which created miniatures, weaponry and armor, and effects vendors in England, Germany and New Zealand, overseen by visual effects supervisors Dean Wright and Wendy Rogers.

“Trumpkin’s hair contained approximately 15 colors of red and blond human hair,” said Berger. “Peter Dinklage had very thick black hair and we didn’t want to bald-cap him every day, so Tami shaved his head and painted it with tattoo colors to disguise five o’clock shadow. Tami then applied a gelatin nosepiece and ears. She bleached his eyebrows, fitted the wig and beard, hand-laid hair to blend into the wig, styled it with hot irons and then set it. We used very few appliances because Peter had such an expressive face. His brows were so emotive, and he had such amazing blue, soulful eyes, he really brought Trumpkin to life.”

KNB also revamped goat-headed satyrs, which in the first film had been portrayed by actors wearing masks with limited facial articulation. “Satyrs were originally designed to be primarily digital creatures,” Berger recalled. “In the eleventh hour, the production decided they wanted more practical creatures on set. That left us with eight weeks to take Weta Workshop’s design and turn that into practical makeups, background heads and suits. We had no time to think about it, we just had to get it done.” Using a new Aaron Sims design, Jeremy Aiello sculpted two new satyr heads. “Instead of placing the satyr’s head where the actor’s head would be, we ‘stove-piped’ it out, so the creature’s head sat forward and above the actor’s head, giving it a more animalistic feel.”

KNB lead mechanical designer David Wogh fitted hero satyrs with radio-controlled facial mechanisms to facilitate jaw, brow, eyelid and eye movement. The mechanized mask fit on a skullcap substructure on top of the actor’s head, permitting vision through fur covering the satyr’s neck. KNB fabricated stretched spandex body suits that fit over a human form with foam latex buildup on the chest and green leggings for CG leg replacements. Artists then hand-painted and applied National Fiber Technology synthetic fur to the suits, and flocked and hand-punched hair onto satyr heads. Hero suits sported hand-tied fur.

KNB also employed a new approach for the half-human/half-horse centaurs, avoiding the prosthetic horse bodies and greenscreen platforms used on the previous film. “Andrew wanted to have actors on stilts or in big boots,” remarked Wendy Rogers. “They had considered using stilts on the first film but safety concerns had prevented it. Just before we started shooting, I was in England visiting vendors when I saw a newspaper article about ‘Powerizer’ exercise stilts. A journalist had written a story about how she first tried on these prosthetic leg extensions, and, after a few hours of practice, could run 20 miles an hour wearing them. I thought it might be worth looking into.” Stunt coordinator Alan Poppleton responded with enthusiasm to the lightweight metal stilts. Powerizers clamped around the lower legs allowed for bouncing gaits and great mobility, and also elevated centaur performers to desired eye-line height. Stability was an issue, however, occasionally requiring the actors to rely on platforms and stages for support.

The Moving Picture Company handled centaur digital enhancements and developed tests to match animated horse bodies to Powerizer motion. MPC animation director Adam Valdez developed centaur run cycles styled on naturalistic horse motions. MPC compositing supervisor Charley Henley and his team assisted centaur gaits by digitally isolating Powerizer actors and retiming their bounce. For swifter galloping moves, animators generated centaurs as fully keyframed CG characters.

The centaurs, satyrs and fauns all made use of a semi-procedural animation rig that MPC developed to rapidly apply creature legs to performers dressed in greenscreen leggings. “We built rigs for all the hybrid characters that matched the human actors wearing Powerizers,” said MPC CG supervisor Clwyd Edwards. “We used that to do all our tracking, matching what was in the plates. Once we matchmoved human legs, we turned those off and switched the others on — and that gave us animated legs that were 70 percent of the way there, tracked to the actor’s hips, with foot



Creature effects designer Howard Berger attends to a practical Aslan head, crafted at KNB and worn on set by creature performer Shane Rangi. The puppet was used to assist with filming scenes in which the digital lion interacted closely with human performers. The practical stand-in guided actor eye-lines and helped to maintain an important emotional connection between characters.



KNB updated creature looks for the second film, paying special attention to Narnians prominently featured in the new adventure. Sculptor John Wheaton works on a clay rendering of a satyr, revised to create a more animalistic feel, with greater articulation.

placement matching the terrain. Animators refined performances for each creature's leg design, making sure the foot positions made the weight of the character feel right."

By the end, MPC had generated more than 20 categories of fully CG creatures, including cheetahs, deer, leopards, hares, wolves and eagle/lion hybrid gryphons, as well as digital doubles of human cast members. Variations of age and gender further multiplied the headcount and required the majority of creatures to be heavily modified from existing models, created for the previous film, or rebuilt entirely.

Among new creatures generated by MPC was Reepicheep, a valiant warrior mouse voiced by Eddie Izzard. To assist with shooting Reepicheep scenes, KNB created full-scale lighting models in both quadruped and biped poses, the latter standing 21.75 inches tall. "Smaller creatures in Narnia are slightly bigger than they appear in the human world," noted Dean Wright. "Larger creatures are generally slightly smaller. That allowed all different sized creatures to interact with our young performers, and it worked well for Reepicheep, allowing him to look fearsome and dangerous when he needed to be."

MPC refined Reepicheep's design digitally, determining how anthropomorphic the character should be. "We looked at a lot of nature reference of mice and rats," said MPC visual effects supervisor Greg Butler. "Rats are much larger than mice, with longer bodies and slightly extended limbs, which would have been useful for Reepicheep in a sword fight. Mice are more peanut-shaped, and if they stand on two legs, their forearms hang down like a T-rex. But Andrew really wanted to keep to mouse proportions because we didn't want Reepicheep to read as a rat." Adam Valdez and lead animator Julio Hernandez developed key poses that defined Reepicheep's mouse-like qualities by widening the reach of the character's forearms and limiting upright postures. "We gave Reepicheep a bit of a curve to his back; and when we did our final skinning and rigging work, we gave him a plump little belly to make him look a bit middle-aged. He



KNB sculptor Jeremy Aiello puts finishing touches to a clay sculpture of Asterius, a minotaur leader in the Narnian army. The production established minotaurs in the previous film, but KNB created a new, more rugged and scarred design for Asterius, featured in a scene in which the minotaur warrior advises the Pevensies and Prince Caspian, exiled heir to the Narnian throne.



Worn by Shane Rangi, Asterius' mechanical mask sat over the performer's head, allowing visibility through the neck. The head had radio-controlled eyes, lip-sync capabilities and hand-tied fur.

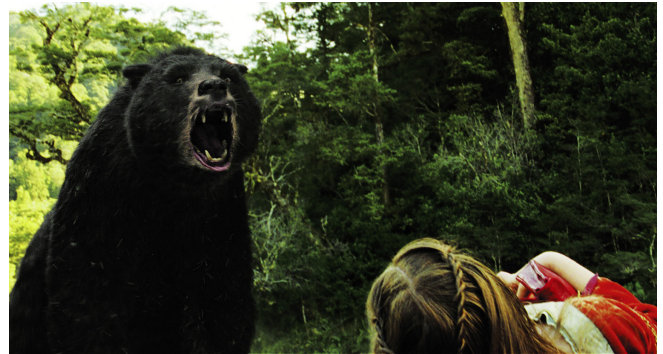
carried his weight down low, and when he ran on all fours he did a little bit of squash-and-stretch — not in a cartoony way, but just enough to give the impression he had a little fat moving through his body.”

Framestore CFC developed a number of key characters, as well, including Trufflehunter (voiced by Ken Stott), a wise old badger and mediator. “Trufflehunter is the Narnians’ voice of reason,” explained Framestore CFC supervisor Jon Thum. “He tries to pull his people together, and he has a lot of important dialogue scenes.”

Framestore CFC developed their character designs in-house, based on taxidermy and nature reference filmed at badger rescues, and then developed badger behavior with animation supervisor Kevin Spruce. “One of the trickiest things was to work out how to make Trufflehunter run from two legs onto four in one shot,” observed Thum. “We worked out models for each configuration, and then designed a rig that was able to do both. To make his lip sync read, we had to exaggerate mouth shapes because a badger’s jaw is located right underneath his face. The black and white fur pattern on the face also made Trufflehunter’s eyes difficult to light because they were located in the black parts of his fur. We generated little eye patches, slightly lighter than the surrounding fur, and controlled those separately in the composite. If his eyes fell into the dark we could brighten them a little, and we animated them as he moved from light to shadow.”

The production also entrusted Aslan, the noble lion king of Narnia (voiced by Liam Neeson), to Framestore CFC. “We used the basic geometry that Rhythm & Hues had created for Aslan to give us all the proportions,” commented Thum. “That was very useful, but we then had to create the animation rig and look-development within our pipeline. I had read reports about how Rhythm & Hues had spent two years working on Aslan’s mane. We had one year, and we had people working on it that whole time.” CG supervisor Mike Mulholland oversaw digital Aslan work, including the fur groom, which proved to be one of the most complex in the company’s history. “The fur of Aslan’s mane was so long it created huge problems for both lighting and dynamics. That took a long time to solve.”

Part of Aslan’s redevelopment involved an increase in size, symbolizing the character’s increased mystical presence. To cater to the size change in on-set interactions, KNB milled a new lion head that was 15 percent larger than the previous Aslan model, and then resculpted details. Lead suit technician Jeff Himmel oversaw fabrication, furring and cosmetic finishing of an Aslan costume that creature performer Shane Rangi wore on set.



Transported back to Narnia, the Pevensie children venture into an unfamiliar landscape where a fierce black bear, reverted to its primal state, attacks Lucy. The production filmed the scene in New Zealand, with Shane Rangi wearing a KNB stand-in bear suit to guide eye-lines and compositions. Weta Digital shot lighting reference and elements of the bear’s feet interacting with the terrain on location, and then generated a digitally animated bear for shots of the beast lunging at Lucy. The animated bear, rigged with skin, muscle and fur dynamics, leveraged Weta’s digital creature technology developed on King Kong.

The lion suit provided director of photography Karl Walter Lindenlaub with important lighting reference and allowed the production to shoot ambitious interactive scenes with young actors. “Georgie Henley, who plays Lucy, was eight years old on the first film,” noted Andrew Adamson. “Back then, talking to a tennis ball was not that far removed from playing with her toys, so her imagination was very open. That being said, we learned that the more realism we could bring to the shoot, the more realism we got from a performance. When Shane wore the Aslan costume, it was not only good lighting reference, it also created an immediate emotional response.”

Dominating the Narnian landscape is Miraz Castle. To design the giant stone edifice, production designer Roger Ford used reference of a 12th-century castle in Valois, France. “Pierrefonds Castle had a lot of elements I was looking for,” related Andrew Adamson. “We considered shooting there because I didn’t want to rely on visual effects for every castle shot. But we discovered that was not going to be practical, and it was going to be difficult for our stunt performers, so we decided to build a large set in Prague. Then we used a miniature to extend that set and show the castle exterior.” The decision to build a practical miniature was based on the high volume of castle shots required, particularly in a 14-minute castle siege sequence at the center of the film. “Miniatures were cost-effective for a large shot count. We also had a great relationship with Weta Workshop from our first film, and we were already doing some work with Weta Digital. The stars aligned, and I think it turned out to be one of the best miniatures that they’ve done.”

Miniature construction coincided with the building of the full-size castle set on the Barrandov Studios backlot, comprised of a multi-level courtyard and a causeway connecting to a village. Visual effects model unit art director Christian Huband and Weta Workshop conceptual designer Gus Hunter produced numerous conceptual renderings of the environment from which Weta Workshop generated maquettes. The final design incorporated towers of stone that sat on a rocky limestone outcrop, surrounded by a river with a village below. Weta Workshop produced the miniature castle in three scales. For wide shots, modelmakers built a 1/100-scale castle surrounded by village buildings and a 40-by-40-foot terrain. For closer shots, modelmakers built the entire castle in 1/24 scale, including a complete rock base and a section of the village, with 1/10-scale additional pieces for detailed foreground work.

To develop animatics for castle scenes, the production purchased a commercially available 1/20-scale three-dimensional paper model of Pierrefonds Castle. Previsualization supervisor Rpin Suwannath and The Third Floor used scans of the model to construct a rough 3D model that Andrew Adamson used to work out story beats. Plowman Craven & Associates later scanned Barrandov sets, characters, props and all European locations and provided Maya files of assets to



The red dwarf Trumarkin (Peter Dinklage) and his irascible associate, the black dwarf Nikabrik (Warwick Davis), become important allies to the Pevensies and to Prince Caspian. KNB gave Narnian dwarves a complete makeover, building facial prosthetics and custom hairpieces for Trumarkin and Nikabrik, and additional makeups for eight other male and four female dwarf characters. To preserve the natural character of the performers’ faces, KNB limited facial prosthetics to gelatin noses and ears.

visual effects vendors. “We color-coded the previz model,” explained Dean Wright, “and we used that to figure out where we needed to build our miniature pieces. As Andrew and his editor tightened up the cut, we updated our previz, which dictated what we shot in miniature.”

Previz allowed Weta Workshop to plan camera access in shots swooping into the castle courtyard, which at 1/24 scale measured little more than three-and-a-half by five feet. “We’ve had problems in the past with making holes in a miniature for the camera to go into,” recalled director of miniature photography Alex Funke. “Miraz Castle was a very precise architectural structure, which had to fit together along seams in the stonework. Richard Taylor’s team carefully built the miniature in pieces on large wooden boxes that slid across the floor. That enabled us to take out portions of the castle, move the camera in, get our low-angle shots and then slide the pieces back exactly where they were supposed to go. With a little touch of colored Plasticine in the seam to heal it up, it was like it had never moved.”

Weta Workshop modelmakers John Baster, Greg Allison and Ian Ruxton worked with Alex Funke’s lead modelmaker Paul Van Ommen to build the miniature as a urethane foam construction. To engineer precisely interlocking sections, Weta recruited local craftspersons skilled in joinery. “I managed to find four people who were very gifted in the refurbishment and building of rare sailing yachts,” Richard Taylor related. “They worked with our traditional modelmakers to bring the level of skills necessary to build the various scale pieces, which had to fit together like an elaborate 3D jigsaw.”

To texture the castle surface, modelmakers generated brick block patterns using photographs from set and then milled patterns in negative on a 200mm-diameter aluminum tube affixed to a 3D rotating bed. “That gave us a continual roller of brick pattern, like a lithographic printing press,” Taylor explained. “It printed brick texture into compressed polystyrene, which we could scale to create different size blocks. We ran a sheet through the machine about every 15 seconds, achieving detail that we would have spent days stamping by hand, not as accurately. We also used that process extensively for stamping long runs of lead for roofing details.”



An important new character in the Narnia universe is the warrior mouse Reepicheep. KNB created lighting models of Reepicheep for reference on set, and Weta Workshop fashioned a tiny rapier with filigreed guard to assist with on-set battle interactions. The Moving Picture Company then created Reepicheep as a digitally animated character.

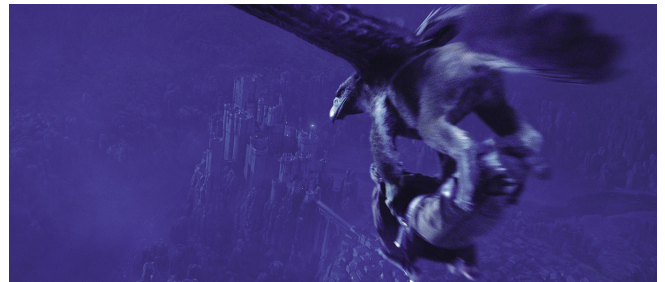


Trufflehunter, a garrulous and wise old badger, ponders a sacred ivory animal horn used to summon the Pevensies back to Narnia. Framestore generated Trufflehunter as a CG character who serves as a Narnian mediator and tactician.

The village surrounding the castle featured 1,000 buildings that Weta Workshop built with its business partner Weta-Tenzan Productions in China. “We constructed prototype 1/24-scale village buildings from art department photographs and blueprints,” Taylor explained. “Weta-Tenzan took silicone molds, made rotationally-cast resin reproductions and a pile of other architectural components. The reason we did this was not for cost-effectiveness; it was for time. We just couldn’t mobilize the huge number of staff we needed to create all the components on our short schedule.” While Weta-Tenzan mass-produced basic village buildings, Weta Workshop created fine detailing and sculpted the terrain. “Our landscape had to match the art department landscape, inspired by some beautiful paintings done by Gus Hunter in the Weta design studio. We used 3D mapping to mill out the landscape, complete with foundation bases ready to accept all the houses.” Paul Van Ommen’s team then dressed buildings and created vegetation using juniper-based tree constructions and miniature trees grown for the model railway hobby industry.

As photography commenced on full-scale sets, Weta Digital tracked plates to provide data for motion control photography of the miniature. “About 60 percent of the castle was shot on the backlot set,” noted Weta Digital visual effects supervisor Guy Williams. “Another 20 to 25 percent was shot on bluescreen stages. The last 10 or 15 percent was completely miniature.” Weta Digital composited castle shots, topping towers with 1/10-scale miniatures, which nested into 1/24-scale castle sections and the 1/100-scale terrain. “The miniature landscape extended out about half a mile. The hills behind the castle blended into matte paintings projected onto 3D geometry, and then we added a CG river around the castle.”

The castle is first seen in its entirety as Caspian rides on horseback, escaping assassins that Miraz has dispatched to kill him. The production filmed the sequence in rural Paradise, on New Zealand’s south island, where an aerial camera swooped down toward horses galloping across a meadow. Weta Digital tracked the plate in 2d3 boujou and passed motion data to the miniatures camera team, which filmed the castle in 1/100 and 1/24 scale. “The foreground was 1/24 scale,” explained Alex Funke. “The background was 1/100 scale. The 1/24-scale village didn’t cover the whole area, so we did a ‘step and repeat’ — shooting a section, moving the camera sideways and repeating the village in another portion of the frame. We used what we called a ‘lost and found’ edge that wandered among the houses so the join wouldn’t show as an obvious split. We shot a matte for that, rotated the set and slid it over so the perspective matched, and made the set twice as big.”

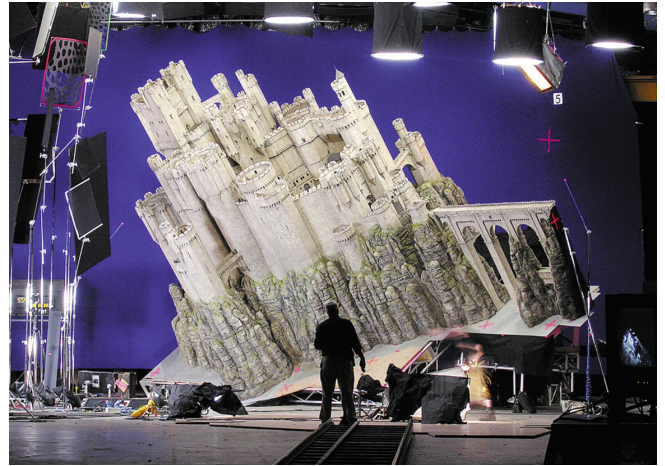


Peter Pevensie (William Moseley) leads Narnians – carried by flying gryphons – in an attack on Miraz Castle. Andrew Adamson choreographed the assault with previsualization supervisor Rpin Suwannath and The Third Floor. Weta Workshop modelmakers constructed various scale miniatures of the castle, which Weta Digital assembled by compositing multiple passes of filmed elements with digital matte paintings. MPC then generated gryphons, adapting digital assets developed for the previous film, and composited the animated creatures with wire-flown live-action passengers.

Weta Digital assembled the miniature and live-action elements with 3D terrain extensions. “Boujou gave us survey information to track on,” stated Guy Williams. “We built CG terrain to blend into those tracking points so the topology lined up. We also had a lidar survey of the miniature set. We made both ends meet by building synthetic terrain in between, and then matte-painted a transition from one to the other. The matte painting disguised the join and the CG terrain disguised the parallax offset.”

Back in *World War II*-era London, the Pevensie children make their way to school at the end of their summer vacation. The production filmed establishing shots of the children entering a period London Underground subway station on location in Prague. “We shot that scene on Národní Trída by the Charles Bridge,” said Dean Wright. “The location had two lion sculptures on either side of a building. Roger Ford designed the station façade right next to those.” Framestore CFC senior digital matte painting supervisor Kevin Jenkins added barrage balloons and a matte painting of Trafalgar Square in the background.

For shots of the children waiting for their train at Strand tube station, the production built a partial greenscreen set in New Zealand. The set included a moving train carriage and a portion of the platform. Framestore CFC expanded the environment with digital extensions and created a magical transition that whisked the Pevensies back to Narnia. “The previz originally depicted the transition in one shot,” related Wright. “We built a circular track, dollied the camera around the kids, and as we did so the train station ripped apart and landed them on a beach in Narnia. We found a beautiful beach in the north island of New Zealand, called Cathedral Cove, which had a natural archway similar in shape to the interior of a tube station. We first shot the kids on stage and then we went out to the beach, rebuilt the track and planned the handoff between the set and the cave.” As the sequence evolved, Andrew Adamson elaborated on the concept, using the arrival of a train to cue the magical disintegration of



Director of miniature photography Alex Funke lines up a 70-foot-long motion control tracking shot of the 1/24-scale Miraz Castle and rock base. When the studio ceiling did not allow sufficient clearance for shots swooping down onto the castle, Funke’s team used a mechanical truss, bolted to the studio floor, to cant the castle structure 35 degrees toward camera.



For wider shots showing Miraz Castle looming over an adjoining village, Weta Workshop built a 1/100-scale castle and 1,000 miniature village buildings, produced in collaboration with Weta-Tenzan Productions in China.

the station as posters and tiles peel from the walls, a bridge above the track is torn apart and Narnia appears through a blinding golden light.

To extend the station and add a train full of people moving through it, Framestore CFC used reference material from the London Transport Museum and photographic surveys of the set as textures, and then animated tiles, posters and debris flying through the frame. Weta Digital generated a shot of the footbridge wrenching apart by generating 'before' and 'after' digital matte paintings and then animated the destruction through a nodal pan. The production photographed the Narnia side of the transition without motion control, approximating a repeat of the move around the Pevensie performers. Framestore CFC designed the transition to the exterior plate using digital projections of station tiles ripping away and stroboscopic glimpses of the CG train intermittently obscuring and revealing the beach.



To film performers carried aloft in gryphon claws for the castle raid, the production employed a four-point flying rig that translated MPC gryphon animation data to a motion control armature that maneuvered actors in front of a bluescreen. William Moseley performs as Peter Pevensie in the flying rig.

In Narnia, the children discover the ruins of Cair Paravel, the castle they previously inhabited as rulers of the land. Roger Ford fashioned a set of broken castle walls on location in Coromandel, New Zealand. Framestore CFC enhanced the environment with a digital matte painting in a wide shot that revealed the castle on an island surrounded by ocean.

The dwarf Trumpkin soon befriends the children and leads them to the mainland where they encounter a Narnia that has reverted to its untamed state. Wearing a stand-in bear suit fabricated at KNB, Shane Rangi performed a scene — shot on location near Wanaka, in New Zealand — in which a black bear attacks Lucy. Weta Digital digitally removed the stand-in and Weta animation supervisor Paul Story keyframe-animated 12 shots of a fully articulated synthetic bear. “We animated the bear with full skin, muscle and fur dynamics,” noted Guy Williams. “It was a somewhat sunny scene in the shadows of the trees and exposures were chosen to make the kids and the forest look as good as possible, so the stuffy bear looked quite dark in frame. That made our digital bear tricky to light. It was similar to a problem we ran into on *King Kong* — lighting a black furry creature in a dark forest setting. We had to make sure we had enough light to see detail so it read like a black bear, not a silhouette.”

Continuing their journey, Trumpkin and the Pevensies make camp in the forest, while Lucy, unable to sleep, encounters magical phenomena that lead her to Aslan as if in a dream. Framestore CFC CG effects supervisor Mark Hodgkins generated effects of birch trees bending apart and a cloud of petals that appears in the shape of a human figure — a ‘dryad,’ as seen in the previous film. “We built onto ILM’s dryad model,” explained Jon Thum. “We used a particle system in Houdini to attract particles to a 3D model and then allowed them to disperse. Leaves and petals took on the shape of a person, forming and un-forming in a very graceful way.”

Andrew Adamson shot Lucy’s and Aslan’s reunion on location in Paradise, New Zealand, with Shane Rangi in the Aslan suit. “Lucy ran up, hugged Aslan, and then rolled around with him on the ground,” said Thum. “The trickiest part for us was the hair interaction, because Georgie’s hair flew all over the place — with no bluescreen. But it was absolutely the best way to shoot the scene because Georgie



For ground-level scenes inside Miraz Castle, production designer Roger Ford built a backlot castle set at Barrandov Studios in Prague. Andrew Adamson prepares for a scene with lead centaur Glendower (Cornell John) – in a KNB EFX prosthetic makeup – who wore Powerizer leg extensions to create a realistic centaur gait. MPC later furnished digitally animated equine legs.



gave us such a great performance.” MPC 2D supervisor Mark Bakowski’s compositing team integrated Aslan using painstaking rotoscope and digital paint techniques combined with digital fur simulations to create interaction with the lion’s fur. As the characters rolled across the ground, Rangi’s body occasionally obscured large portions of Henley’s lower body, which required extensive digital paint and restoration. “We painted out Shane’s legs and then replaced the lower half of Georgie’s body by patching in bits from other takes and from later in the sequence, and warping them into place. It was complicated, but fortunately our 2D team was very experienced.”

A hooded werewolf urges Caspian to use dark magic to seek aid in the battle against Miraz. For long shots of the hooded werewolf, KNB fitted creature performer Shane Rangi with a custom mechanical mask and prosthetic body suit complete with latex musculature and hand-tied fur. For ambulatory shots, or closeups in which the creature throws back its hood, Weta Digital created a digital werewolf with proportionally shorter legs, thinner musculature in the limbs, and expressive canine articulation in the face and muzzle.

Aslan settles into conversation with Lucy. Andrew Adamson shot the scene closely observing the stately lion’s interactions with the young girl. “Andrew often performed Aslan’s lines on set,” said Wendy Rogers. “That enabled him to interact with Lucy in the way he wanted Aslan to behave, although we were never able to get him to wear the Aslan head! There was a wonderfully subtle emotional performance between Lucy and Aslan. Framestore CFC was painstaking in achieving a believable level of physical and emotional interaction between the characters.”

“We spent a lot of time on Aslan’s performance,” asserted Jon Thum. “Our face and muscle animation rig enabled us to nail his lip sync pretty quickly. A lot of his character came from the shape and the look of his eyes. They really sold the performance. It took a lot of back and forth to fine-tune the animation, dialing it back, but also making sure the animators were getting the most out of it. The other important factor was the dynamics of the mane. As Aslan moved his head or took a breath, the mane had to react in a believable way. It had to appear to be alive.”

The Pevensie children soon meet the motley creatures of Narnia who debate plans to align forces with Caspian against Miraz. Among the creatures is a troupe of aggressive mice accompanying Reepicheep, created by MPC. MPC differentiated between mice by applying subtle alterations to their basic Reepicheep model with varieties of fur grooms achieved in the studio’s in-house fur system, Fertility. “Reepicheep has two lieutenants, Peepiceek and Ceepiceep,” Greg Butler explained. “We did specific design work for them. For the nine other mice in the posse, we did Photoshop designs and populated those across the group, incorporating features from Reepicheep and his lieutenants, giving them an overall familial relationship.”

Narnians take refuge inside an overgrown stone barrow, known as ‘Aslan’s How.’ The production built a 30-foot-tall portion of the exterior of the How on location in the Czech Republic. MPC enhanced the set with digital matte painting extensions. “The location had a 360-degree tree-line and mountains in the background,” related Butler. “We added a CG cyclorama and, in aerial shots, filled in the skies and digitally removed the nearby town of Ústí nad



Labem.” MPC extended the structure using a 3D model rendered with texture projections and digital vegetation. “Most shots of the How used a digital matte painting projected onto a 3D object to create parallax. A handful of shots involved crane moves and helicopter shots. They required a full 3D rendering of the How, with full digital grass and 3D trees.”

MPC used Furtility to grow moss and grass across the terrain, and generated 3D trees in three species indigenous to the locale. “We modeled the tree trunk and main branches coming off the trunk,” explained Clwyd Edwards. “We populated those with secondary branches, twigs and leaves. Then we pruned the trees and arranged the layout of the foliage to create oaks, beeches, and hornbeams. We then rigged the models procedurally and applied a dynamics system to make them blow around.”

After an antagonistic meeting with Prince Caspian, Peter Pevensie (William Moseley) rallies Narnians in an assault on Miraz’s castle. The castle attack was a significant addition to the book, conceived to underline tensions between Peter — former Narnian high king — and Caspian. “The idea for the sequence came from a scene in the book where they talk about sorties that happen along the way to the great battle,” noted Andrew Adamson. “I felt the lack of description there gave me license to introduce something I hadn’t seen before, which was a medieval castle being attacked by mythological creatures. It gave us opportunities to show fauns as fighting leaping ninjas, minotaurs charging through human armies — a whole new series of images.”

Adamson worked with Rpin Suwannath’s previz team to conceptualize the castle siege as a nocturnal airborne attack, with flying gryphons airlifting characters into the castle. To film characters in the grip of gryphon claws, motion control specialist Ian Menzies devised a flying rig for a bluescreen shoot at Barrandov. “MPC exported their gryphon animation for motion control,” explained Andy Fowler. “Ian Menzies’ rig mimicked those moves, carrying actors as they hung from a puppet rig that pulled on their limbs as if they were being pulled by a gryphon.”

Design changes in the sequence required several attempts to create a naturalistic flying rig configuration, arriving at a four-point harness slung beneath a motion control armature on a crane. Motion control operator Andrew Bull translated gryphon moves to the flying rig. The motion control camera moved around performers, creating the illusion of movement through frame. “The rig recreated the effects of every little nuance and wing flutter in the gryphons,” noted Dean Wright. “We could lift actors up and down and create very subtle motions that made them feel like they were flying

Edmund Pevensie (Skandar Keynes) stops Caspian (Ben Barnes) from summoning the White Witch (Tilda Swinton) – a powerful evil sorceress vanquished by the Pevensies in the first film – who materializes inside a doorway that magically fills with ice. The production filmed the scene with Swinton on set, clad in a partial costume with bluescreen leggings, lit from below in front of a bluescreen. Weta Digital then used a cyberscan of Swinton to generate a 3D model of the White Witch in the ice, adding flowing hair, a long dress and icy vapor streaming over her body.



Lucy, her siblings and Caspian converse with Reepicheep and the Narnian mouse posse. The MPC creature team

through different areas of the castle, not just hanging on wires.”

The gryphon flying sequence evolved simultaneously on three continents. “MPC fed animation from London to Wellington,” stated Wright. “Alex Funke’s team programmed moves and shot tests to make sure the camera move looked good on the miniature. Alex sent that test back to us in Prague where our animators on set tweaked that information to Andrew’s specifications. Andy Bull handed that data to Ian Menzies, and then we shot it.”

Castle miniature photography used multiple lighting passes to replicate the color palette of first unit photography. “We used the exact same color temperature that Karl Walter Lindenlaub used in Prague,” remarked Alex Funke. “He used slightly corrected HMI lighting to create a very cold moonlight. We used tungsten lighting filtered to that same color temperature so it required a minimum of color shifting to match the image on the negative.” Castle plates averaged between 11 and 14 repeat passes, depending on the level of detail in the shot. “It broke down into basic lighting elements, beauty pass, smoke, bluescreen mattes, sconces, windows, and what we called the ‘flash pass’ — an absolutely dead-flat lighting of the set, the ugliest thing you’ve ever seen, but useful for compositors because every bit of detail was lit up. If they needed to brighten an area of the image, they used the flash pass as a little portable piece of fill light.” Weta Digital 2D lead Colin Alway assembled castle plates, layering miniature, scenic elements and atmospheric. Weta then transmitted completed backgrounds to MPC, where Charley Henley’s team inserted flying gryphons.

One of the most complex shots in the castle siege involved an aerial view of a castle tower where Edmund Pevensie (Skandar Keynes) is cornered by Telmarines. “The live-action consisted of Edmund and the door on a bluescreen set,” remarked Funke. “We set that into a 1/10-scale miniature, backed up by another 1/10-scale tower, backed up by a 1/24 section of the castle — and we did a huge crane move to reveal the fact that he is very high up, with no way to escape. The guys are breaking down the door to get at him, and he’s doomed. It was a classic piece of dramatic storytelling that involved layers of miniature in a craning corkscrew camera move that rose up the equivalent of almost 300 feet in the real world.” Weta Digital used CAD data of the miniature and Plowman Craven lidar scans of the full-scale set to align miniatures and digital environment extensions. MPC then added an animated gryphon that swooped in to rescue Edmund.

MPC handled approximately 100 shots in the castle siege, including extensive Powerizer leg replacements. “Weta Digital did all the backgrounds and we did all the foregrounds,” stated Greg

created two lieutenants and nine other mouse warriors to accompany Reepicheep in battle, adapting the main hero mouse model and creating varieties of fur grumps in the studio’s in-house fur system. Fertility Reepicheep and his clan in quadrupedal and bipedal poses to help establish compositions and scale.



Miraz’s Telmarine army prepares to attack Aslan’s How, an ancient barrow where Caspian and the Narnian army take refuge. Weta Workshop created armor and weapons for the Telmarine and Narnian performers. The production shot the conflict on location in the Czech Republic using several hundred infantrymen, 40 horsemen and partial props representing the lower portions of Telmarine war machines. MPC digitally enhanced battle scenes, replicating war machines digitally around the field, and covering the terrain with digital characters representing 1,000 Narnians and 5,000 Telmarines. Digital characters were animated using the studio’s Artificial Life Crowd Engine – A.I.C.E. – and keyframe techniques.

Butler. “We had combinations of keyframe animation of digital double Telmarines, live-action stunt work, bottom halves of all the hybrid characters — fauns, satyrs, centaurs, minotaurs — as well as shots where we were far enough away to run A.I.C.E, our ‘Artificial Life Crowd Engine,’ to generate Narnians and Telmarines fighting. It had everything in it!”

Back at Aslan’s How, a bird-faced hag (Klára Issová) and a hooded werewolf (Shane Rangi) urge Caspian to seek aid from the White Witch (Tilda Swinton), whose powerful spirit has been awaiting reawakening since her defeat in the previous film. KNB EFX provided prosthetic makeup for the hag and mechanical pieces for the werewolf. “They only wanted the practical werewolf for three or four shots,” said Greg Nicotero, “but we thought we’d try to push it a little further. Aaron Sims came up with a design that really broke the human form. Jeff Himmel and Beth Hathaway fabricated a full body suit, with hand-tied fur. David Wogh built a mechanical werewolf mask that sat stovepipe fashion above the actor’s head, with the jaw and face protruding forward.”

In closeups and full ambulatory shots, Weta Digital generated a digital werewolf. “We tried to retain as much of the practical werewolf as possible,” said Guy Williams. “We only replaced the face if he was talking. Quick shots when he was in the background were all practical. When he flipped off his cloak, the front of the werewolf’s body, his legs and arms were exposed. We made the legs a little shorter, and made the arms about 70 percent longer, with thinner biceps and thighs, to create an even more inhuman shape.”



Minotaurs, satyrs and centaurs pour out of Aslan’s How to engage Telmarine aggressors. The production clad human/animal hybrid performers in KNB prosthetics and blue leggings covered with tracking markers that allowed MPC to track and digitally remove the actors’ lower portions before attaching animated animal legs. Powerizers allowed centaur performers to intermingle freely with their bipedal counterparts on the battlefield.

The werewolf uses a claw to draw a circle on the chamber floor and, with the assistance of the hag, causes the White Witch to materialize inside a 12-foot sheet of ice. Tilda Swinton performed the scene in Prague wearing bluescreen leggings, with her hair pulled back in a skullcap. Weta Digital used a cyberscan of Swinton to generate a 3D model of the White Witch in the ice. “Tilda was a trouper,” commented Williams. “We gave her a little wire-frame tracking marker crown to wear so we could track her head. We added CG hair, CG dress, CG smoke flowing down her body. We wanted her to appear ethereal, so we played with her transparency — the ice started cloudy and then became clearer until she was revealed. The hard part was dealing with the refraction, distortion and highlights of facets inside the ice. We rendered everything using ray-tracing and volumetric effects.”

Edmund prevents the White Witch from fully taking form by stabbing a sword into the ice. Prague special effects supervisor Gerd Feuchter’s team shattered sheets of resin on set as reference. The New Zealand miniatures unit staged further practical elements for Weta Digital. “The miniatures crew rigged a full-size shipping container as a freezer,” Williams explained. “They made up two sturdy heavy metal frames two-and-a-half-meters tall, a meter-and-a-half wide, and 100 millimeters thick, and then froze half a ton of water into each one. The ice sheets stood vertically in a bluescreen set which matched the live set. They used a pneumatic ram to impact the rear of the ice and broke four sheets, filmed from three camera positions.” 2D lead Charles Tait then integrated the practical elements with 3D simulations of shattering ice.

The final confrontation between Telmarines and Narnians takes place outside Aslan’s How. The production filmed the conflict in a field outside Ústí, with a Telmarine cavalry charge staged in an adjacent location. The busiest shooting days involved some 150 Narnians in makeup, 40 horsemen and 200 infantry. MPC then enhanced the crowd to 1,000 Narnians and 5,000 Telmarines by mingling live-action with keyframe-animated characters and A.ICE crowd simulations. “The more practical elements you can have in your image,” observed Wendy Rogers, “the easier it is to make the audience feel that the CG characters are alive. So we always filmed large numbers of Narnian extras on set with first unit — centaurs, fauns, minotaurs, satyrs and dwarves. All the other Narnian quadruped characters were CG, but we always tried to frame animated characters with living people, to make them feel like they were part of the same world.”

The A.ICE crowd simulations were derived from motion capture sessions with Giant Studios in Los Angeles and at Audiomotion Studios in England. Centaur motions were achieved as simultaneous



The production also used a variety of rigs and platforms, including a motorized chariot, to enhance performer stability in shots requiring less interactive centaur behavior.

horse-and-rider combinations. “The rider was seated forward over the withers of the horse,” explained Rogers. “With his feet and knees back in the saddle and his back a little bit arched and leaning forward, it placed him close to where his body was supposed to be in relation to the horse.” MPC then applied the natural dynamics of horse and rider motions, with offsets, to a CG centaur skeleton.

For high aerial shots passing over the battle, MPC populated the terrain with swarms of A.ICE agents interspersed with the practical crowd. “We used the live-action if a hero cast member was visible on the field,” said Greg Butler. “For the Telmarine army, we usually kept at least the front row or a block of extras. In several shots we painted out the crowd entirely because they were not matching continuity. But the live-action crowd was always useful reference.”

MPC also enhanced flying projectiles and full-scale props of Telmarine war machines across the battlefield. “There was a device like a trebuchet,” observed Butler. “It wasn’t a traditional medieval trebuchet; it was Andrew’s own idea for a double-firing mechanical catapult device that we called a ‘trebuchet’ because it was the closest fit. The production built the lower third of it on set with the wheels, base and loading mechanism, and we topped that off in CG. In wide shots they were fully digital.”

Weta Workshop created armor for Telmarines and Narnians and mass-produced 2,500 weapons, including a tiny sword for Reepicheep. While overseeing animated battle action, Adam Valdez was drafted into acting with his own creation. “Adam had grown facial hair during shooting,” noted Andrew Adamson. “He looked like a Telmarine, so we suited him up and had Reepicheep kill him. I thought that would pretty much guarantee the best possible animation in that shot.”

MPC animation and crowd simulation teams used keyframe animation for foreground battle action and A.ICE crowd motion for backgrounds. “It was a pretty seamless blend between A.ICE and our hero digital doubles,” observed Clwyd Edwards. “If we decided a character was too close up for the medium-resolution textures that we used in A.ICE, we turned him into a full-resolution guy, retaining all his animation.” A.ICE sampled character assets, randomizing armor, helmets, skin tones and fur grooms to create varieties through the crowd.

In the heat of battle, Narnian tree creatures — known as ‘battle dryads’ — also spring to life to pick off Telmarines. The production staged practical interactions of roots grabbing Telmarines by executing ratchet pull gags on stunt performers. MPC on-set supervisor Tom Wood filmed elements of exploding earth on set. Compositors then combined practical elements with dynamic simulations of churning mud as trees ambulate through the ground, their roots pushing earth away. “We wanted to create the impression the trees had some kind of spirit in them,” said Greg Butler. “When one of the battle dryads is struck by a rock from a trebuchet, its leaves form a face that screams to camera briefly.”

Telmarines retreat to a bridge spanning an adjacent river. There, they fall prey to an elemental creature — a 120-foot-tall Narnian river god composed entirely of water, which obliterates the Telmarines by tearing the bridge from its foundations. The production filmed the sequence at a river in Slovenia where Roger Ford created a 70-foot-long, 14-foot-high timber bridge capable of supporting Telmarine troops. “We first shot the bridge and Telmarine camp with second unit and an

aerial unit,” said Wendy Rogers. “The main unit then came in and we completed scenes with our heroes and Narnian extras. After that, the construction team removed a third of the bridge and for two days we shot scenes of the bridge under construction. Then, in a one-and-a-half-day turnaround, they removed even more of the bridge and we shot the aftermath of the bridge destruction scenes.”

Third Floor previsualizations guided the Slovenia bridge shoot. To capture high-angle plates above the bridge, Wendy Rogers accompanied second unit director John Mahaffie in a helicopter shoot that hovered above members of Alan Poppleton’s stunt team and then swooped down towards the men as they reacted to the river god. Later, on the Barrandov Studios backlot, the special effects team built a portion of the bridge on a hydraulic motion base. The production then filmed closeups against bluescreen of Telmarine leader Lord Sopespian (Damián Alcázar) and his men reacting in terror.

Framestore CFC generated digital matte-painted backgrounds of the bridge environment and initiated development of the digital river creature. Scanline VFX took the creature to completion, leveraging its experience in digital fluid simulations on Poseidon and 300. “The river god was a very exciting concept for us,” remarked Scanline visual effects supervisor Stephan Trojansky. “We had seen beautifully done water horses in *The Lord of the Rings*, and immense breaking waves in Poseidon or *The Day After Tomorrow*, but the challenge here was to build a creature that evolved out of the river, sucking up the river, constantly struggling to keep its shape as a living creature. Its liquid volume was in constant motion, flowing and heaving to and fro with the momentum of its body motion. Each shot was affected by the character’s explicit motion; and on top of that, all the simulations reacted to its motion.”



Edmund, Peter and Caspian join the fray, charging towards the Telmarines with minotaurs, satyr, centaurs and dwarves, while Susan Pevensie (Anna Popplewell) directs a battery of faun archers from a balcony above the entrance to Aslan’s How. Roger Ford’s team erected a 30-foot-tall façade representing the exterior entry to Aslan’s How on location in the Czech Republic. The structure was designed as a sacred monument, erected on the stone table site of Aslan’s slaying in the previous film, now overgrown after centuries of neglect.

Third Floor developed post-viz of the 3D animated character, compositing a rough 3D figure over edited background plates. Scanline then developed tests using its fluid simulation engine, Flowline, to define the river god's features in vortices of water and foam. "The vortex motion poured up through the shoulders into the arms," explained Scanline CG supervisor Ivo Klaus. "The hair was a waterfall that poured out of his head. The brows had little foamy rivers flowing on the forehead. The beard was made up of waterfalls that emerged out of the cheeks. As water from the hair and beard hit the shoulders it created breaking waves and turbulence that sucked back up into the head and flowed out again. It was a continual cycling motion where not a drop of water was lost."

The interplay of water required a complex simulation rendered in a single pass, without multiple composited layers. "There was only so much direction we could give to the natural physics simulations," noted Andrew Adamson. "If we tried to over-direct them, they stopped looking organic. It became a very iterative and experimental process."

Effects artists defined base water motions using rough simulations that required, on average, ten seconds render time per frame. Flowline tools known as 'element directors' then allowed the artists to apply more detailed forces to polygonal shapes representing water volumes. The simulations eventually built up into a network of proxy geometries that controlled a single larger simulation that required gigabytes of data to render each frame. "The proxy resolutions allowed us to control the higher resolution data on the render farm," explained Trojansky. "We didn't have time to wait more than half a day to render our big simulations. It took three weeks to develop our first shot of the river god for the teaser trailer, but we did the final iteration from scratch, including the compositing, in one day."



MPC enhanced the Aslan's How set using a 3D model rendered with texture projections and digital vegetation. Wide shots featured a digital matte painting projected onto the structure, while more dynamic swooping shots required 3D-rendered architectural details. MPC used its in-house fur simulation engine to grow moss and grass, and generated three species of trees based on indigenous flora. MPC fit hybrid Narnian creatures with digitally animated leg extensions, and further enhanced the charge with a menagerie of keyframe-animated quadrupeds, including bears, cheetahs, deer, hares, leopards and wolves.



The Telmarines' retreat over a bridge is blocked when a Narnian river god rises up, smashing timbers and drowning infantry and cavalry. To film the sequence, Roger Ford's team constructed a full-scale bridge and Telmarine encampment on location in Slovenia. After filming was complete on the intact bridge, crews partially dismantled the structure for scenes of the bridge under construction and in its destroyed state. Framestore then generated digital matte-painted backgrounds of the environment. Scanline VFX generated bridge destruction and the river god using powerful digital water simulations to define a 120-foot-tall creature.

Effects artists refined simulations for 22 shots of final production footage, rendering caustics, occlusion, refractions and reflections derived from high dynamic range surveys of the Slovenia location. “The river god was an extremely complicated effect,” noted Wendy Rogers,” but the tools that Scanline developed allowed us to focus on the shots creatively so we were not limited by our toolset.”

Scanline VFX rendered the character as a single volumetric element that blended into plates with Telmarines and backgrounds. Scanline 2D visual effects supervisor Gabriel Dedic and his team of compositors replaced the existing river with a CG river that dis-placed its volume into the river god. For shots of the river god uprooting the bridge, effects artists created dynamic simulations of bridge timbers that bent and splintered. Drowning Telmarines were created using digital doubles with keyframe animation, motion capture and rag doll simulations.

Narnians celebrate the Telmarine defeat with Aslan and Caspian presiding over a gathering in the village adjoining Miraz’s castle. Andrew Adamson declared the celebration shoot ‘family day’ and invited cast and crew members to make cameos with their loved ones. The KNB team devised makeups for Tilda Swinton and her family, who appear as a family of centaurs. Howard Berger’s eldest son and daughter played Telmarines and his young son Jake appeared as a faun. Dean Wright’s family was featured prominently in a parade, filmed against bluescreen.

Framestore CFC added Aslan, Trufflehunter and a talking squirrel named ‘Pattertwig’ to the throng. MPC provided Reepicheep and additional animated characters. Weta Digital composited miniature village backgrounds that represented Narnia’s rebirth. “The terrain around the village was very bleak until the celebration,” commented Alex Funke. “Miraz would not allow for any vegetation. But now, everything had to be blossoming and beautiful. We dressed the miniature village with much more greenery, adding moss growing in the rocks, and lit it with much warmer and softer light to make it feel like a rejuvenated world.”

Aslan guides the Pevensies to a withered oak tree that magically transforms, its twisted trunk opening to reveal a portal through which the children return to their world. Framestore CFC animated the tree untwirling and generated effects for the transition back to London. “We had to shoot the ‘B’ side of the transition first during our New Zealand shoot,” said Dean Wright. “The camera lingered on Lucy as she walked through the portal and dollied around her as she walked into the station, stopped and looked back. Many months later, we shot the ‘A’ side in Prague.”

Framestore CFC shot reference frames of Lucy, tracked the camera move and then supplied motion data to an Arrimotion motion control rig in Prague. Georgie Henley repeated her actions, following



Telmarine leader Lord Sopespian (Damián Alcázar) looks into the face of the elemental river god. For closeup shots of Sopespian and his men reacting and tumbling to their deaths, the production filmed performers on a portion of the bridge built on a hydraulic motion base with a bluescreen backing at Barrandov. The Third Floor developed ‘post-viz’ of a 3D animated character over edited background plates. Scanline then imbued the river god with character by orchestrating water flows to create the impression of a fierce countenance with a waterfall of hair and a gushing foamy beard in constant churning motion.

markers on the floor, duplicating her pacing and expression. “The important part was the transition in the moment of the shot,” stated Jon Thum. “We checked our still frames to make sure that Georgie’s head lined up perspective-wise, and then we morphed her head to join the two takes.” The transition was complicated by a continuity error. “Unfortunately Georgie’s hair had been brushed different ways in each take, and a morph between her hairstyles would never have worked. We ended up tracking her hair from one plate to the next.”

As postproduction drew to a close in Europe and New Zealand, preproduction began on the third Narnia film, *The Voyage of the Dawn Treader*, under the aegis of director Michael Apted. “The next film is scheduled to start shooting in January of next year,” revealed Dean Wright. “I’m handing the reins over to visual effects supervisor Jim Rygiel, who is going to live in Narnia for a while. We’ve already started giving files to Jim and his animation staff. They are going to be using some of our elements, particularly Reepicheep, who is very prominent in the next story.”

With the conclusion of the second Narnia film, Andrew Adamson remains involved with the franchise in the capacity of a producer, continuing his personal attachment to the source material, which has guided adaptation of the books to balance fantasy trappings with the more intimate story of the Pevensie children. “I have always tried to find the heart of each story,” Adamson affirmed. “C.S. Lewis wrote the Narnia books in a style that somewhat skimmed the surface of his story, so any adaptation has to dig a little deeper. Prince Caspian was more of a boys’ film with more action than the last one, but there was also a sense of the characters trying to recapture something that they’d lost. That gave the story a bitter-sweetness that I could relate to emotionally. Beyond that, the visual spectacle just served the story.”

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